ABSTRACTS

Presented by IAGLR

March 16-17, 2022
Cleveland | Virtual

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International Association for Great Lakes Research

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2022 State of Lake Erie Conference

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International Association for Great Lakes Research
4840 South State Road
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ABSTRACTS

An alphabetical listing of abstracts presented at the 2022 State of Lake Erie Conference, organized by first author. Presenters are underlined.

A

ALFORD, A., FULTZ, R., Lake Erie Islands Nature and Wildlife Center. **Increasing Island (Wild) Life Knowledge Through Community Engagement and Science: The Lake Erie Islands Nature and Wildlife Center**.

The mission of the Lake Erie Islands Nature and Wildlife Center (LEINWC), located on South Bass Island in the Western Basin of Lake Erie, is to promote conservation of and education about the flora, fauna, and lands of the Lake Erie Islands ecosystems. From 1993-2003 LEINWC was the site of a private museum collection of North American fish and wildlife. The collection had a long-standing tradition of educating South Bass Island visitors and residents about species such as Grizzly Bear, Moose, and the charismatic Mustelids. At the retirement of the collection owner, the LEINWC was formed as a non-profit education center in 2008. Currently, we are working towards centering our programming to meet public education challenges related to plastic pollution, pollinator declines, and animal diversity that directly impact the islands of Lake Erie including the Bass Islands and Kelleys Island. This past year, thanks to a multi-year fundraising effort, we were able to add live animal exhibits that highlight native species such as Midland Painted Turtles, Northern Map Turtles, Pumpkinseed Sunfish, Rock Bass, and Eastern Fox Snakes. We are increasing accessibility to in-the-field programming with summer nature camps and weekly guest lecture events. Most importantly, our community science programming is also gaining strong momentum. Visitors are welcome to learn and report about Island birds and geology through our "Explorer Pack" programming. We hope to develop additional community science programming for the 2022 season that engages in-person and virtual visitors to the Islands in assessing mammal activities through a series of web-enabled cameras. Our greatest support comes from Island residents that have a strong sense of stewardship of the Islands and its wonderful natural treasures. We strive to honor their dedication by being a hub of nature education and public science for the millions of Western Lake Erie Islands visitors.

ALFORD, B., Ohio State University. **Monitoring Harmful Algal Blooms in Lake Erie Using Charter Fishing Captains**.

Since 2013, the Ohio EPA and OSU's Stone Laboratory have incorporated the help of trained charter fishing captains in the western basin of Lake Erie to obtain water samples that are analyzed for harmful cyanobacteria and associated cyanotoxins. During April - October each year, trained captains who volunteer for the program collect a sample at the end of their fishing day using standard OHIO EPA protocols. Samples are stored and picked up weekly and transported to Stone Laboratory. The samples are then processed by Stone Laboratory's water quality,research team, and the data are made public on the organization's website. This community science effort has been beneficial to lake managers and researchers working to understand cyanobacteria blooms and how to alert the public when blooms become toxic. Overall, the data suggest that microcystin toxin concentration, the most prolific of the cyanotoxins in western Lake Erie, tends to peak during

August. Phosphorus concentration tends to correlate well with algal concentration (i.e., bloom size). However, the charter captain data also suggest that cyanotoxin concentration does not correlate with harmful algal bloom size. Subsequently, studies are now being conducted to better understand the behavior of cyanotoxins in Lake Erie. For example, research at Stone Laboratory and its collaborators is being carried out to determine if nitrogen concentration leads to greater toxicity of blooms, regardless of bloom size.

ALSIP, P.[1], ROWE, M.[2], LIU, S.[1], VANDERWOUDE, A.[2], SAYERS, M.[3], [1]University of Michigan Cooperative Institute for Great Lakes Research; [2]NOAA Great Lakes Environmental Research Laboratory; [3]Michigan Tech Research Institute. **Modeling suspended sediment and light attenuation in Lake Erie**.

Developing ecological models for Lake Erie requires adequate representation of its complex light environment due to the importance of light-dependent processes like primary production and the visual foraging of predators. However, inter- and intra-basin differences in sediment resuspension and the abundance of dissolved and particulate organic material in the water column—the primary factors affecting light attenuation—complicates efforts to characterize the availability of photosynthetically active radiation (PAR) throughout the lake. The linkage of ecological models to spatially explicit hydrodynamic models has become a valuable means for studying complex aspects of limnology. We applied a sediment resuspension model and General Ecosystem Model linked to the Finite Volume Community Ocean Model to study how sediment resuspension, phytoplankton, and dissolved organic carbon (DOC) affect the attenuation of PAR throughout Lake Erie. We will present examples demonstrating the model's skill in simulating recurrent and episodic spatial patterns in light attenuation, suspended sediments, and DOC by comparing it to satellite-derived values and in-situ observations. These suspended sediment and light attenuation models may be linked to phytoplankton, lower food web, and biogeochemistry models to support adaptive management of nutrient inputs and fisheries.

AMIDON, Z.[1], DEBRUYNE, R.[2], MAYER, C.[1], ROSEMAN, E.[2], SAKAS, A.[3], [1]University of Toledo; [2]U.S. Geological Survey; [3]The Nature Conservancy. **Lake Whitefish Egg, Larvae, and Juvenile Monitoring in Lake Erie Reveals Critical Survival Window**.

Globally, coregonine fishes are experiencing population declines. These declines are broadly attributed to poor survival during the early life history stages, however specific mechanisms are difficult to discern due to the breadth of possible factors. To narrow the bottleneck window for Lake Erie's Lake Whitefish population and identify probable mechanisms, vital statistics of eggs, larvae, and juvenile life stages were measured. During the fall of 2016-2021, eggs were sampled at 42 locations throughout the western basin to assess abundance and distribution. Post-hatch pelagic larvae were collected weekly from 2017-2019 and 2021 at 27 locations and compared with similar data from 1995-1998, a time when adult Lake Whitefish were recruiting to the commercial fishery to assess differences in abundance, distribution, and growth. Fall age-0 and age-1 juvenile abundances from 1990-2020 measured by the Ohio Department of Natural Resources fall trawl surveys were analyzed for patterns related to year class age and environmental conditions. We found that available spawning habitat is likely not limited because eggs were collected throughout the western basin. Recent larval abundances were of similar magnitude as 1995-1998, indicating that contemporary Lake Whitefish embryos successfully hatched and survived to the pelagic larval stage with potential to recruit to older age classes. Comparisons of juvenile abundances suggests that cohort strength may be set by fall age-0. Therefore, the recruitment bottleneck in Lake Erie likely occurs during or after the pelagic larval stage and before the first fall. This narrowing of the bottleneck window highlights the value of early life stage monitoring that can help identify specific mechanisms

affecting coregonine recruitment and benefit management efforts to reverse local and global coregonine population declines.

ANDERSEN, G., Varacet, Inc. **HAB prediction using the water microbiome**.

We are developing a DNA and RNA-based technology to provide an early warning system to predict harmful algal blooms (HABs) before they happen. Currently, chemical and physical measurements have provided limited capability in providing predictive analysis of pending HABs. What has been missing from the existing testing methods are the important role of microbes in the formation of HABs. Monitoring the entire water microbiome, including all algal species allows us to detect the microbiological shifts that precede an algal bloom. The water microbiome is the collection of the tens of thousands of distinctive types of bacterial species, as well as other microbes, that are present in any natural body of water. A vast majority of these microbes are harmless and part of the normal functioning of any lake system. However, a subset of these microbes interacts with, and can predict when there is a potential for a pathogen or toxic algae to proliferate. Our PhyloChip technology provides a microarray-based approach to accurately and reproducibly identify and quantify all bacteria, including the cyanobacteria responsible for the HABs, in any water sample. The data from the microbiome analysis using the PhyloChip can be used in combination with other analytical methods to provide more accurate forecasts of HABs in Lake Erie as well as to evaluate the effectiveness of mitigation efforts.

APP, M., Great Lakes Data Watershed. **Enabling Student and Citizen Scientists with Universal Data Access**.

The Great Lakes make up the largest body of fresh water on Earth and the quality of this water directly affects the economy and personal well-being of 30 million people. While there is a large amount of data that tells us about the quality of the water in the Great Lakes, this data is not readily accessed by organizations, scientists or citizens. Multiple access problems including inconsistent formats, lack of metadata, unknown locations, poorly designed APIs and overly complex security impede this access and significantly reduce the critical value and insights this data can provide. While professional researchers are significantly hampered by these challenges, they often have training and associates that can help them painstakingly accumulate the necessary data for specific studies. For part-time volunteers these barriers to the data are insurmountable. When we think of how citizens and students contribute, we often limit their role to gathering field data. While gathering data is a necessary and valuable service, many students and citizens can contribute much more but are hindered because of this lack of data access. The Great Lakes Data Watershed (gldw.org) was created to make this data easily and universally accessible. GLDW provides access to many public data sources and station types including USGS, NDBC, GLOS, HOBO Onset, Fondriest NexSens, Hyfi, Flume and StreamLabs. In addition, new data sources can be quickly and reliably added. Combining this simple, consistent and universal data access with rapid dashboard development tools, GLDW can both dramatically increase the productivity of researchers and scientists while at the same time enabling students and citizens to become scientists. GLDW encourages everyone to dive into the entire watershed of public data, develop dashboards, analyze, investigate and collaborate. By significantly broadening the community of "scientists" to include volunteers we will be better able to understand and protect our Great Lakes.

B

BADE, D., Kent State University. **Annual maximum microcystin concentrations in Western Lake Erie predicted by early season total phosphorus concentrations**.

Microcystin has been the primary toxin of concern with harmful cyanobacterial blooms in Western Lake Erie. A relatively long-term (~10 years) data set now exists to study annual microcystin dynamics. While the areal extent of the cyanobacterial blooms in Lake Erie has been well predicted by models using spring phosphorus loads, there exists no annual predictions of bloom toxicity. Moreover, a large bloom extent does not equate to high microcystin concentrations. Using data collected by the Ohio Environmental Protection Agency at 8 sites in Western Lake Erie between 2011 and 2015, microcystin concentrations were compared with nutrient concentrations to explore possible relationships and establish predictive models. The maximum concentration of total phosphorus, dissolved reactive phosphate, or nitrate measured at a site early in the season (before July) explained a large portion of the variation in the maximum microcystin concentration which occurred later in the season (e.g. for TP, r = 0.87). A linear regression model was developed from the first five years of data using early season total phosphorus concentration to predict maximum microcystin concentrations. This model was applied to the eight sites in subsequent years (2016-2019). In those subsequent four years, observed microcystin values were within the prediction intervals for 28 of 32 comparisons. Due to the log-normal distribution of the microcystin concentrations, prediction intervals can be quite large for an individual site and therefore potentially lacking some value for managers. A "worst case scenario" for the Western Basin was also examined by comparing the maximum TP value from all sites with the maximum microcystin concentration from all sites for a given year, resulting in another strong relationship (r=0.9). Nitrogen dynamics may also aid in predicting toxin dynamics. When ammonium is present at detectable concentrations, microcystin tends to be low or undetectable. Microcystin concentrations tend to peak when nitrate is still present and then declines after nitrate becomes undetectable. These data suggest that traditional nutrient monitoring in Lake Erie can be very useful in understanding the annual toxicity of blooms. Especially important is rapid turnaround of the lab analysis to allow for timely predictions.

BADER, J.[1], MAY, J.[2], HELLER, K.[3], [1]Case Western Reserve University; [2]University of Akron;[3]Kent State University. **Smart Citizen Science Curriculum Project**.

Despite living on the shores of a Great Lake, too many students have no emotional nor intellectual connection to Lake Erie or its connected watersheds. Many students, particularly those in large urban school districts, have never even visited any of the Great Lakes even though they may live less than a mile away from one. The Smart Citizen Science Curriculum Project aims to link middle and high school students with the Smart Citizen Science Initiative (SCSI). The SCSI is a multi-faceted strategy aiming to ensure the long-term health of Lake Erie by engaging citizens and broadening access to reliable mechanisms to measure key physical and water quality parameters. Coordinated by the Cleveland Water Alliance in collaboration with a large number of community partners, the SCSI combines standardized data collection with an online data platform to allow citizen scientists of all ages to contribute valuable data to a common database. Our theory of action is to use curriculum modules delivered in a formal school setting to link underserved students with the field work completed in an informal setting through the SCSI. The content of each of the three modules developed in early 2021 is aligned with a major theme of the Smart Citizen Science Initiative, namely (a) climate change and harmful algal blooms, (b) ecosystem assessment, and (c) digital fabrication. Upon completion of the initial drafts of each module, 25 community partners and interested teachers reviewed and provided feedback in summer 2021. Ten teachers from across the

Lake Erie basin are currently taking 4-6 weeks to pilot each module, provide feedback, and share student work. The Gelfand STEM Center at CWRU is coordinating the process of collecting feedback from both teachers and students that will be used to revise the modules in early summer 2022. Next steps are to disseminate the revised curriculum modules throughout the Lake Erie watershed through professional development trainings for one cohort of 30 teachers in summer 2022 and a second cohort in summer 2023. We will also provide support during the implementation of intensive environmental education experiences for students during the 2022-23 and 2023-24 academic years.

BAILEY, J.[1], O'DONNELL, D.[2], HOOD, J. M.[1], [1]Ohio State University; [2]University of California, Davis. **Changes in zooplankton phenology in Western Lake Erie, 1995-2020**.

Climate warming has altered the phenology of many animal species; however, we have a poor understanding of how phenology is simultaneously shaped by interactions among warming, eutrophication, and other physiochemical and biological controls. For example, animal populations in the western basin of Lake Erie have been influenced by multiple stressors over recent decades including harmful cyanobacteria blooms, warming, declines in ice cover, and invasive species. The influence of these patterns on zooplankton are particularly important to understand since the timing of zooplankton biomass dynamics could influence both top-down controls on phytoplankton and energy availability to vertebrate and invertebrate planktivores. Here, we characterize the patterns and examine the controls on the phenology of four zooplankton taxa (Daphnia retrocurva, Skistodiaptomus oregonensis, Mesocyclops species, and Dreissenid veligers) at four to eight sites in the western basin of Lake Erie during 1995–2020. These taxa were selected as representatives of the major mesozooplankton (> 200 μm body length) taxonomic groups which were frequently both present and exhibited high relative abundance during May–September when data was collected. Two of these four taxa exhibited changes in phenology. The peak biomass of D. retrocurva occurred earlier (~10 days decade-1) while S. oregonensis peak biomass occurred later in the year (~25 days decade-1). In contrast, the phenology of Mesocyclops sp. And Dreissenid veligers did not change during 1995-2020. However, Dreissenid veliger phenology did vary among sites, and all four taxa exhibited high variation in peak biomass during 1995-2020. We will also discuss how intra-annual changes in D. retrocurva and S. oregonensis phenologies are related to cyanobacteria blooms and temperature. Our results contribute to understanding of the complex controls on zooplankton phenology and biomass dynamics and provide a starting point for understanding how climate change and eutrophication, two important drivers of global change, might influence food web dynamics in freshwater ecosystems.

BAKER, T.[1], MILLER, C.[2], HAIMBAUGH, A.[2], GEORGE S.[3], GUPTA, S.[2], SPERONE, F.[2], [1]University of Florida; [2]Wayne State University, [3]University of Wisconsin. **Persistent contaminants of emerging concern in water, sediment, and fish in a Great Lakes urban-dominant watershed**.

Within the Great Lakes, contaminants of emerging concern (CECs) have been detected in urban surface waters. Understanding the human and ecological health consequences of environmentally-relevant exposures to persistent CECs, particularly as complex mixtures, is essential. Surface water and a limited number of sediment samples were collected over two years (Spring and Fall 2018 – 2019) at multiple locations in the Lake Huron to Lake Erie corridor to investigate more than 150 CECs. Surface water was analyzed for pharmaceutical and personal care products (PPCPs), pesticides, and per- and polyfluoroalkyl substances (PFAS). Sediment was analyzed for PFAS. Fifty compounds were detected at ng/L or ng/kg levels. In Summer 2020, additional sites were added, and surface water and sediment samples were collected and analyzed for

28 PFAS compounds. In Summer 2021, to assess bioaccumulation of PFAS in wild fish and the potential human-health implications, we analyzed the concentration of 40 PFAS from muscle and serum samples of fish representing different trophic levels along the Lake Huron – Lake Erie Corridor. These results will be presented and inform follow-up studies on persistent contaminant mixtures and multiple stressors, and offer science-based priorities and evaluation objectives for natural resource and public health agencies/initiatives.

BARTLETT, A., BLUKACZ-RICHARDS, E.A., GENDRON, A., GILROY, E., GRAPENTINE, L., MILANI, D., OUELLET, F., TARANU, Z., TETREAULT, G., Environment and Climate Change Canada. **Using aquatic ecological endpoints to assess agricultural practices in the Lake Erie Basin**.

The Living Laboratory Initiative was launched by Agriculture and Agri-Food Canada to provide an integrated approach to agricultural innovation, bringing farmers, scientists, and other partners together to co-develop, test, and monitor agricultural best management practices (BMPs) and new technologies in a real-world context. The Lake Erie Basin was identified as a priority for the Ontario Living Laboratory, and common BMPs of interest were continuous cover and reduced tillage. One aspect of assessing the impact of BMPs at the watershed level is using aquatic ecological endpoints to evaluate water quality and the overall health of aquatic ecosystems within agricultural areas of the Lake Erie Basin. A paired study design has been implemented to compare watersheds with a high adoption of BMPs to those with low adoption of BMPs in geographically similar regions. Two pairs of watersheds were selected based on location within the Lake Erie Basin (uplands versus lowlands) and ability to leverage established watershed monitoring sites/projects and historical data: Upper Medway Creek (high BMP) and East Medway Creek (low BMP) in the uplands, and Wigle Creek (high BMP) and Big Creek (low BMP) in the lowlands. Multiple lines of evidence with both field- and laboratory-based approaches are being used to assess aquatic ecosystem health, including: analysis of resident aquatic invertebrate communities, aquatic invertebrates exposed in situ, water and/or sediment toxicity to invertebrates, fish communities and fish health, and long-term changes in aquatic communities and nutrients. In addition, an intensive sampling effort at Wigle Creek is ongoing to evaluate the movement of pesticides from soil to creek during precipitation events. These activities encompass various time scales in order to examine short-term (seasonal), intermediate (between years), and long-term (decadal) changes. An overview of our approach and progress to date will be presented.

BARTOLOTTA, J.[1], HARDY, S., [1]Ohio Sea Grant. **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.

BELLAMY, A., MILLSAP, D., APPLEGATE, J., U.S. Fish and Wildlife Service. **Examining fish tumors and deformities in Ohio AOCs to assess effectiveness of management actions**.

US Fish and Wildlife Service examined the prevalence of fish tumors and deformities in the spring of 2021 to help inform a decision about removal of the tumors and deformities Beneficial Use Impairment (BUI) in the Cuyahoga River, Black River, and Maumee Areas of Concern (AOCs). Contaminants in water and sediment, particularly polycyclic aromatic hydrocarbons (PAHs), have been linked to an increased occurrence of external and internal tumors in fish across Great Lakes AOCs. Management actions including the removal of contaminated sediment should eventually lead to a decrease in tumor prevalence if there are no additional continuous sources of contamination. In order to assess the current status of fish tumor prevalence in Ohio AOCs, brown bullhead catfish were collected from each of Ohio's AOCs and liver tumor prevalence was determined through histopathological analysis. Fish community composition and the prevalence of deformities, eroded fins, lesions, and tumors (DELTs) were also examined that summer. Comparison of 2021 tumor prevalence data with data from previous years indicates a relatively steady decline in the percentage of liver tumors across each of the AOCs.

BENESH, K.[1], BANERJI, A.[2], LUDSIN, S.[3], BOLGRIEN, D.[2], BOWEN, K.[4], BUSCH, K.[3], COLLINGSWORTH, P.[5], COTTER, A.[2], CURRIE, W.[6], HOOD, J.[3], RUDSTAM, L.[7], WATKINS, J.[7], HOFFMAN, J.[2], [1]Oak Ridge Institute for Science and Education; [2]U.S. Environmental Protection Agency; [3]Ohio State University; [4]Fisheries and Oceans Canada; [5]Purdue University; [6]CFO Canada; [7]Cornell University. **Preliminary findings from the Lake Erie CSMI regarding stable isotope-based measures of food web changes associated with harmful algal blooms**.

Harmful algal blooms (HABs) dominated by cyanobacteria can have profound effects on ecosystem metabolism, nutrient cycling, and species distribution by altering habitat suitability (e.g., water clarity, toxin exposure). The combined effect of HABs on food webs is not well understood in most ecosystems, however, in part owing to both the complexity of potentially interacting effects and complexity of trophic transfers. Elemental stable isotope ratios, especially for carbon, nitrogen, and sulfur, offer an approach to study system-level effects of HABs because they can provide an integrated perspective on metabolism, nutrient cycling, and diet of higher consumers (e.g., fish). Harmful algal blooms have become a persistent feature of Lake Erie during summer. For the 2019 Lake Erie CSMI field year, we measured stable isotope ratios of dissolved inorganic carbon (DIC), particulate organic matter (POM), zooplankton, and select prey and predator fishes. Baseline samples for the lower food web (DIC, POM) were collected lake-wide, whereas zooplankton and fish were sampled in the western basin both inside and outside HABs. Data analyses are ongoing, however preliminary results revealed distinct patterns. Lower food web samples showed baseline differences across the major basins, consistent with changes in both nutrient cycling and metabolism. Future analysis will aim to integrate fish community and diet data with stable isotope data to better understand how energy, nutrients, and trophic interactions are collectively affected by HABs.

BERG, J., Biohabitats. **Payment for Delivered Ecosystem Services to Improve Runoff Quality from Agricultural Lands**.

Payment for delivered ecosystem services is a significant tool in our toolbox to funding restoration efforts that have significant values to society, where most of the restoration work needs to occur on privately held land. This approach involves an entrepreneurial partner putting together one or a series of projects focused on delivering identified benefits (e.g., nutrient reduction) and offering this service to a funder for a unit price ($/lb reduced). If the funder values this opportunity,

a contract is entered into to pay the unit cost agreed upon for the reduction delivered. The entrepreneurial partner assumes all risk, including obtaining land owner commitments, design, permitting, construction, monitoring to demonstrate reductions obtained, and any post-construction maintenance. The benefits that the funder receive include assignment of all risk and project management to the entrepreneurial partner. Only after the project has been successfully implemented and the contracted services documented, is the funder obligated to pay for the service. The funder realizes the lower unit cost benefits that come from a partner experienced in delivering projects. These projects can be more quickly brought to completion, with less than 2 years required from the contract agreement to substantial completion. All permit responsibilities reside with the entrepreneurial partner. The entrepreneurial partner has a broader ability to incentivize participation by property owners than government programs, with one tool being direct payments to the property owner. The entrepreneurial partner has capabilities and experience in project financing and real estate tools that can be incorporated to provide a range of flexibility to the funder. The presentation will discuss several payment for delivered ecosystem services projects currently being used in the Chesapeake Bay Watershed to reduce phosphorus, nitrogen and sediment pollution. One project er will discuss is funded by the State of Maryland, another by the State Highway Department, and a third by local government. The basis for calculating reductions will be described, and we will document the cost benefits realized with this tool in comparison to standard projects solicited, awarded, and managed by funders.

BERG, J.[1], DENBOW, T.[1], ARVAI, B.[1], PARKS, J.[1], HOEHNE, S.[1], THOMSON, G.[3], KRATT, K.[2], SAKAS, A.[5], SCUDDER, M.[4], [1]Biohabitats; [2]Tetratech; [3] Baird; [4]Ohio Department of Natural Resources; [5]TNC. **Living or Nature-Based Shorelines in Sandusky Bay, Ohio: Designs for Water Quality and Habitat Improvements**.

Sandusky Bay is a 64 square mile embayment of Lake Erie situated between Cleveland and Toledo. The Sandusky River is the major upland inflow and the combined inflow of the Sandusky River and Sandusky Bay is 1828 square miles, approximately 75% of which is tilled cropland. Excess nutrient loads from cropland, poor sediment controls, and historic wetland conversion to cropland and diked duck ponds has largely eliminated ecosystem nutrient uptake and sediment trapping services historically provided by coastal wetlands. As a consequence, Harmful Algal Blooms (HABs) frequently occur in the summer, creating human health concerns, fish kills, and a host of other problems. As a consequence of this situation in Sandusky Bay, Maumee Bay, and other coastal areas in Ohio, the State of Ohio has recently established the H2Ohio Program, aimed at improving aquatic resources, beginning with water quality. While the projects covered in this poster are all "In Bay" solutions, the H2Ohio Program is also investing in upland restoration interventions, including floodplain reconnection, wetland restoration, agricultural BMPs, and other approaches directed at reducing nutrient and sediment export to coastal waters. Biohabitats, and our partners Baird Engineering and TetraTech, have worked on several living/nature-based shoreline projects in Sandusky Bay as a result of these efforts to improve aquatic resource conditions. The variety of project designs developed include upland anchored living/nature based shorelines; offshore coastal barrier islands sheltering coastal wetlands; delta-forming designs at stream inflows to the lake that passively trap sediment and support the development of wetlands; offshore islands that reduce wave and current energy and support development of flow through wetlands and shallow water habitats; and a variety of other restoration elements (e.g., Wave Attenuation Devices [WADs], improved hydrologic connections in diked coastal wetlands, reconnection of streams to riparian wetlands, etc.). The designs are supported by incorporation of existing data, collection of additional site information, modeling of design effects (hydrology and hydraulics, wind wave and current

attenuation, sediment particle transport, nutrient assimilation, wetland community development, etc.), establishment of performance and monitoring metrics, and projected cost benefit analysis.

BERKOWITZ, J., BUFKIN, S., HURST,N., VANZOMEREN, C., U.S. Army Corps of Engineers.
A multi-scale framework for evaluating wetlands in a nutrient reduction context.

Wetland soils have a natural capacity to sequester nutrients and are often employed to improve water quality. However, wetland phosphorus (P) retention capacity is finite and may be limited by legacy P effects. This presentation describes a framework designed to identify, evaluate, and operate wetlands developed for P retention within areas targeted for P reduction. Our approach: 1) estimated soil P storage capacity (SPSC) at proposed wetland locations to quantify site suitability; 2) evaluated P sorption isotherms under varying environmental conditions to elucidate temperature and redox effects; 3) analyzed the potential of soil amendments to increase P sorption capacity; 4) is utilizing mesocosms to model field operational scenarios, and 5) is transitioning these findings to a field-scale R&D wetland in Maumee River Basin. Collectively, these studies help to inform the design, management, and operation of wetlands to optimize P retention. Results suggest SPSC provides a useful screening tool for site prioritization. Additionally, P sorption studies highlight environmental effects on P retention and report that amendments can extend the P-removal life of constructed wetland sites when the un-amended soil sorption capacity has been exceeded. In summary, incorporating multi-scale assessments of P dynamics from bench top studies to field applications will help resource managers estimate the P reduction potential, suitability, operational efficiencies, and estimated lifespan of constructed wetlands.

BICKMAN, S.[1], PETROU, C.[1], MACDONALD, B.[1], LEWIS, G.[1], LOCHHEAD, M.[1], BULLERJAHN, G.[2], BUCHHOLZ, S.[2], BARKER, K.[2], DOUCETTE, G.[3], CHAFFIN, J.[4], JOHENGEN, T.[5], VERHAMME, E.[6], BRIDGEMAN,T.[7], [1]LightDeck Diagnostics; [2]Bowling Green State University; [3]NOAA; [4]Ohio State University; [5]University of Michigan; [6]Limnotech; [7]University of Toledo. **Rapid detection of microcystin and cylindrospermopsin toxins generated from harmful algal blooms**.

Harmful algal blooms (HABs) are a significant and growing problem threatening fresh waters globally. Cyanobacterial HABs (CHABs) contribute to more than $2 billion in annual US economic losses and the estimated annual cost of CHABs in western Lake Erie (WLE) alone exceeds $65 million. CHABs necessitate 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. LightDeck's patented technology enables simultaneous and quantitative detection of microcystin and cylindrospermopsin toxins in a rapid test. End-users can expect a rapid analysis protocol similar to strip tests, but with higher resolution results that are comparable to enzyme linked immunosorbent assay (ELISA) tests. The test provides real-time results, leading to immediate decisions about public-safety. Data on the development of this test will be presented along with data demonstrating the performance of this test with natural water samples. This test was developed with support from the US National Science Foundation and the National Oceanic and Atmospheric Administration/National Centers for Costal Ocean Science (NOAA/NCCOS). It is being tested in collaboration with researchers from Bowling Green State University, NOAA/NCCOS, Ohio State University, University of Michigan, University of Toledo, and Limnotech.

BIHN, S., RAFF, Z., MEYER, A., Lake Erie Waterkeeper. **Animal Agriculture & Surface Water Quality in the Maumee Basin of Lake Erie**.

Research examines the effect of increased animal agriculture on surface water in the Maumee Watershed in the Western basin of Lake Erie using sub watersheds of the Maumee with high CAFOconcentrations with available data that measures total/dissolved phosphorous 2005 to 2018 with measurement by hydrogeological units (HUC) 12 by month and year. The research will be completed by the conference. The report includes a watershed map that reports water quality at the sub watershed levels highlighting areas where water quality is impaired because of livestock exposure. This research follows a similar published report in 2021 in the Journal of Environmental Management, "Shifts in precipitation and agricultural intensity increase phosphorus concentrations and loads in an agricultural watershed," completed in the spring of 2021, This report on Animal Agriculture & Surface Water Quality in the Maumee Basin of Lake Erie will provide charts, figures, tables for public dissemination and will be featured on the Lake Erie Waterkeeper web site (www.lakeeriewaterkeeper.org).

BINION-ZUCCARO, A.[1], SEARCY BELL, K.[2], RAMBOLL, BLAIR, C.[2], PATTERSON, K.[3], [1]U.S. Army Corps of Engineers; [2]Ohio Environmental Protection Agency; [3]Partners for Clean Streams. **Otter Creek Great Lakes Legacy Act Cleanup: Advancing Progress in the Maumee Area of Concern (AOC), Ohio**.

The Otter Creek Great Lakes Legacy Act (GLLA) cleanup project started as a local initiative to address oil sheens observed in the creek. The creek runs through an industrial area before it empties into Maumee Bay, and its industrial past resulted in sediment contamination in the form of bioavailable polycyclic aromatic hydrocarbons (PAHs), adversely impacting benthic organisms. Sediment remediation at Otter Creek was the final action to remove the degradation of aesthetics beneficial use impairment and address multiple others. The local initiative brought together private, state, and federal entities together to address the contamination. Investigations were conducted between 2006 and 2012 by government agencies. This information was used to characterize the sediment and delineate the remediation. Non-federal partners completed a feasibility study in 2013 and signed a project agreement with the U.S. Environmental Protection Agency (USEPA) in 2016 to begin design. In 2020, the design was completed with the collaboration of the port authority, non-federal partners, local stakeholders, and government agencies. Under the Great Lakes Restoration Initiative, the USEPA in partnership with non-federal partners, funded a $7.2M project to dredge contaminated sediment from the lower 1.7 miles of the creek and in a 5-acre area of the confluence. Work was implemented under GLLA via a USEPA contract, with support from U.S. Army Corps of Engineers project management and construction oversight staff. The Ohio Environmental Protection Agency and U.S. Fish & Wildlife Service provided environmental consult regarding habitat improvements for the project and construction was completed by JF Brennan. Collaboration between project partners resulted in a seamless cleanup. Over 50,400 cubic yards of sediment was hydraulically dredged within 3 months. After dredging, a one-foot sand cover was placed within areas of the dredged creek to provide a clean barrier to any remaining residuals, and habitat structures were installed to re-establish wildlife.

BOCANIOV, S.[1], SCAVIA, D.[2], VAN CAPPELLEN, P.[1], [1]University of Waterloo; [2]University of Michigan. **Long-term phosphorus mass-balance analysis reveals a major role of in-lake processes in the re-eutrophication of Lake Erie**.

Though the trophic conditions of lakes are tightly coupled to the external nutrient loadings from their watersheds, in-lake processes play an important role in modulating the cycling of the nutrients. These processes can loosen the watershed-lake coupling, especially in situations when the

external nutrient input fluxes become smaller. To be successful, water quality management of lakes therefore requires a more integrated lake-watershed approach that builds on an improved understanding of in-lake processes that can potentially attenuate or even reverse the water quality improvements expected from watershed nutrient abatement measures.
Despite significant efforts spread over many decades to reduce external phosphorus (P) loads, Lake Erie has been showing symptoms of accelerated re-eutrophication demonstrated by increasing frequency, severity, and spatial extent of cyanobacterial harmful algal blooms, bottom-water hypoxia, and outbreaks of nuisance benthic algae. To help unravel the possible drivers of Lake Erie's re-eutrophication, we conducted a detailed analysis of the long-term water and P mass balances for the entire lake, as well as for each of its three distinct basins. We show that the known external inputs (from upstream Lake Huron, the lake's watershed, and atmospheric deposition) and losses (sediment burial and lake outflow) are not in balance: the losses significantly exceed the external inputs. To maintain the balance between external inputs and losses there must be large additional, but currently unidentified, fluxes of P generated within the lake. In our presentation, we will present the first quantitative characterization of the additional supply fluxes and discuss the most plausible in-lake processes responsible for producing them.

BOHRER, G.[1], JU, Y.[1], YAZBECK, T.[1], MISSIK, J.[1], KUJAWA, H.[1], VILLA J.[2], WRIGHTON, K.[3], RILEY,W.[4], [1]Ohio State University; [2]University of Louisiana, Lafayette; [3]Colorado State University; [4]Lawrence Berkeley National Laboratory. **Methane emissions and carbon sequestration in a Lake Erie estuarine wetland**.

Carbon sequestration is one of the key ecological co-benefits of wetlands. Methane emissions reduce the overall benefit of greenhouse-gas regulation by wetlands. To maximize the overall climate-regulation co-benefits, a wetland design should strive for reducing methane emissions, while maximizing carbon uptake. Methane emissions and carbon sequestration rates have very high spatial variability within the wetland, and vary strongly between ecological patches and hydrological conditions. This high variability makes the carbon fluxes of wetlands hard to predict, and therefore hard to account for a-priori when designing a wetland.
We used an eddy covariance system to conduct long term observations of methane and CO2 fluxes over a large footprint at Old Woman Creek, a Lake Erie estuarine coastal marsh. We made point-scale flux measurements at different vegetation and hydrological patches within the wetland. Our observations show that long-term (inter-annual) changes of wetland water depth, which are driven by increasing Lake Erie water elevation, are affecting both CO2 and methane flux at the whole-wetland scale. At the patch scale, both hydrology and vegetation type control carbon fluxes. Our results are used to develop a patch-level model for predicting methane and CO2 fluxes. Such a model can be used to optimize the design of wetlands with regards to climate regulation services.

BOSSE, K.[1], SAYERS, M.[1], SHUCHMAN, B.[1], LEKKI, J.[2], TOKARS, R.[2], [1]Michigan Tech Research Institute; [2]NASA. **Remote Sensing as a Tool to Assess the Impact of the COVID-19 Shutdown on Lake Erie Water Quality**.

The states of Michigan and Ohio issued shutdown orders in mid-March 2020 in an attempt to slow the spread of the coronavirus (COVID-19), resulting in widespread disruption to economic and human activity. Similar shutdowns in other countries resulted in observable improvements in air and water quality due to declines in industrial pollution, wastewater discharge, and boat traffic. In collaboration with NASA, MTRI researchers utilized satellite remote sensing data from the Visible Infrared Imaging Radiometer Suite sensor onboard the Suomi National Polar-orbiting Partnership satellite to investigate whether these changes in activity led to any short-term changes in water quality in the western basin of Lake Erie (WBLE) by comparing 2020 data to a historic (2012-2019)

baseline. The water quality parameters examined included concentrations of chlorophyll-a (CHL) and total suspended solids (TSS), water clarity, and harmful algal bloom (HAB) extent. WBLE experienced reductions in CHL and TSS concentrations at the basin-wide scale, though the impact varied based on proximity to the Detroit and Maumee Rivers. The HAB extent was also reduced relative to the historic baseline. However, this investigation found that the COVID-19 shutdowns were likely not a direct driver of these anomalies. Instead, co-occurring anomalies in hydrological and meteorological conditions (e.g., lake temperature, river discharge, and wind speed) appeared to be more responsible for the detected water quality changes. This method was extended in 2021 to monitor water quality changes throughout all five Great Lakes. Going forward, utilizing this approach as imagery becomes available will allow for the identification of water quality anomalies in near real time, providing a better understanding of the historical significance of any given sediment plume or phytoplankton bloom and guiding in situ sampling efforts.

BOWEN, K.[1], CURRIE, W.[1], LUDSON, S.[2], WATKINS, J.[3], RUDSTAM, L.[3], HOOD, J.[2], [1]Fisheries and Oceans Canada; [2]Ohio State University; [3]Cornell University. **Western Lake Erie harmful algal blooms and zooplankton spatial distribution during CSMI 2019**.

During the summer, the western basin of Lake Erie frequently experiences harmful algal blooms (HABS), exacerbated by elevated nutrients from the Maumee River and other anthropogenic sources. Although these blooms have received much attention from both the public and the scientific community, less is known about their impacts on zooplankton and trophic transfer from plankton to fishes. As part of the Lake Erie CSMI, multi-agency lower food web and fish trawling surveys were carried out in July and August 2019 when HABS were well established in the southwest portion of the basin, and again in September after they had dissipated. Here we will examine how zooplankton communities differ spatially inside and outside of the blooms, and how biomass and taxonomic composition in these zones change across the season. In August, zooplankton biomass within the clear waters of the Detroit River plume was often low but variable and was dominated by Daphnia retrocurva, Bosmina and Dreissena veligers, whereas within the HABs, taxonomic composition was typically dominated by copepods, including diaptomids and Mesocyclops, and herbivorous cladocerans such as Daphnia galeata mendotae, Eubosmina and Diaphanosoma. We also examine day-night differences in zooplankton biomass and composition, as catch rates of some large predatory zooplankton taxa such as Mesocyclops, Leptodora and Bythotrephes may increase at night. Finally, we will explore whether large zooplankton and predatory cladocerans in particular may be less vulnerable to fish predation within the blooms, using planktivorous fish population estimates and diet data from the trawl surveys.

BRAMBURGER, A.[1], REAVIE, E.[2], ALEXSON, E., [1]Environment and Climate Change Canada; [2]University of Minnesota, Duluth. **Phytoplankton Stable Isotope Signatures of Lake Erie, 2019**.

In many stable isotope food web reconstructions, there are enormous error bars around the 13C and 15N biplot position labled "phytoplankton." Many factors can influence the stable isotope signature of this food web component, including station, depth, season, and taxonomic composition of the sample. As part of the 2019 CSMI Lake Erie field year, we quantified size-fractionated stable isotope signatures for phytoplankton for a number of sites in Lake Erie across 2 cruises (April and August), encompassing nearshore and offshore zones. Phytoplankton isotopic signatures differed markedly between seasons and size fractions, as well as among sites. These findings were similar to those from the other Great Lakes during their respective CSMI field campaign years, and bear important implications for "anchoring" the base of food web reconstructions.

BRIGGS, A.[1], BELORE M.[2], HARRIS, C.[1], HESSENAUER, J.-M.[1], SLAVIK, E.[2], THOMAS, S.[1], TOWNE, K.[3], WILLS, T.[1], WRIGHT, G.[3], [1]Michigan Department of Natural Resources; [2]Ontario Ministry of Northern Development, Mines, Natural Resources, and Forestry; [3]U.S. Fish and Wildlife Service. **Year One of a Collaborative Lake St. Clair Fishery Assessment**.

Lake St. Clair is a large body of water with a diverse and economically valuable fishery. Due to its size and constantly changing ecosystem, the Lake St. Clair fishery is difficult to monitor. Several agencies have conducted fishery surveys in Lake St. Clair and while they are complementary, they have not been part of a coordinated effort. In 2021 the Michigan Department of Natural Resources (MDNR), Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry (Ontario), and U.S. Fish and Wildlife Service (USFWS) began a coordinated fishery survey effort that will continue for several years with multiple survey gears being used on a rotational basis. Mini-fyke nets were used in July of 2021 to characterize the nearshore small fish community with Ontario conducting 40 sets on the Canadian side of the lake, MDNR conducting 40 sets on the northern half of the U.S. side of the lake, and USFWS conducting 30 sets on the southern half of the U.S. side of the lake. Approximately 27,000 fish were caught representing 46 species. Bluegill (Lepomis macrochirus), Largemouth Bass (Micropterus salmoides), Smallmouth Bass (Micropterus dolomieu), and Gizzard Shad (Dorosoma cepedianum) were the most common species. At-risk species caught during the survey included Pugnose Shiner (Notropis anogenus), Northern Madtom (Noturus stigmosus), and Spotted Sucker (Minytrema melanops). Overall fish catch rate was 10 times higher on the Canadian side of the lake, likely related to better nearshore habitat. 90% of net sets on the U.S. side were along hardened shoreline (sea wall or rip-rap) whereas 53% of sets on the Canadian side were along hardened shoreline. This coordinated survey effort will continue in 2022 using large-mesh gill nets.

BUDNIK, R.[1], BUSCH, K.[2], HARRIS, C.[1], KULASA, M.[1], PICZAK, M.[3], COLLINGSWORTH, P.[4], CURRIE, W.[5], HOFFMAN, J.[6], WATKINS, J.[7], BOLGRIEN, D.[6], BOWEN, K.[5], COTTER, A.[6], HOOD, J.[1], MANUBOLU, M.[1], RUDSTAM, L.[7], LUDSIN, S.[1], [1]Ohio State University; [2]Miami University; [3]Carleton University; [4]Purdue University Illinois-Indiana Sea Grant; [5]Fisheries and Oceans Canada; [6]U.S. Environmental Protection Agency; [7]Cornell University. **Cyanobacteria bloom effects on the feeding ecology of western Lake Erie's fish assemblage**.

Harmful algal blooms dominated by cyanobacteria (HABs) pose a threat to Lake Erie's food webs and the fisheries they support. While recent research has shed some insight into how HABs can affect fish habitat use and foraging behavior, much remains to be learned if agencies are to fully understand whether HABs need to be considered when managing their fisheries. Toward this end, we compared the foraging habits of common fish species that were sampled inside and outside of HABs in western Lake Erie during summer 2019. The species studied included gizzard shad (Dorosoma cepedianum), emerald and spottail shiners (Notropis atherinoides and N. hudsonius, respectively), white perch (Morone americana), and yellow perch (Perca flavescens). Sites classified as HABs were dominated by cyanobacteria (Microcystis spp.), contained detectable microcystin levels, and had lower water transparency relative to non-bloom sites. In brief, our findings revealed both expected and unexpected differences between fish species composition, diet composition, consumed prey biomass, and prey-selectivity inside and outside of HABs. Collectively, our findings demonstrate that HABs appear to strongly affect fish habitat use and foraging, highlighting the need to further explore their impact on fish populations and aquatic food webs.

BURLAKOVA, L.[1], KARATAYEV, A.[1], MEHLER, K.[1], HINCHEY, E.[2], [1]SUNY Buffalo; [2]U.S. Environmental Protection Agency. **Lake Erie Monitoring: Can video imagery help delineate benthic habitats?**

Large lakes of the world are sentinels of global and local change and are particularly exposed to anthropogenic and climatic stressors. The story of Lake Erie is a classic example of how profoundly human activity can affect the structure and function of an ecosystem, and continued monitoring is critical for tracking human-induced changes occurring in the lake. Benthic macroinvertebrate communities are among the most useful indicators for biological assessment of environmental and anthropogenic stressors, but our ability to quantify benthic populations is constrained by small spatial scales of traditional grab sampling and time- and labor-intensive processing. During the 2019 lake-wide assessment of Lake Erie's benthic community we studied lake benthoscapes by enhancing the traditional collection of Ponar grabs at 68 stations with underwater imagery, water quality, and sediment nutrient data. Four major habitats were identified from video data including dreissenid aggregations, mayfly Hexagenia spp. burrows, and biogenic structures ("chimneys" and "tubes"). All four habitats differed in near-bottom dissolved oxygen (DO) concentration, with the highest DO levels recorded above dreissenids and the lowest in chimney habitats. DO, turbidity, and surface chlorophyll concentration provided the largest contributions to the MaxEnt model that predicted distribution of identified benthoscapes. There was a significant separation of benthic species by selected benthoscapes, and species associations within habitats were confirmed by independent cluster analysis of species taxonomic data based on index of association. Suitable habitat for Dreissena was limited to normoxic areas in the western and eastern basins, and Hexagenia habitats were predicted only in the western basin. The central basin, subject to periodic hypoxia, was mostly characterized by tube and chimney habitats. The agreement among biological, video and abiotic data sets confirmed that video analysis can provide a quick and reliable method to detect habitats affected by hypoxia.

BURROWS, M.[1], LIVERNOIS, J.[2], WOOD, G.[4], BRATTON, J.[3], [1]International Joint Commission, Great Lakes Regional Office; [2]University of Guelph; [3]LimnoTech; Conservation Ontario (Ret). **Addressing nutrient-related impacts in Lakes Erie and Ontario under the GLWQA: An assessment of progress to date.**

2022 marks the 50th Anniversary of the Great Lakes Water Quality Agreement (GLWQA), as well as 10 years since the GLWQA was last amended, including with a focus on nutrients in the Great Lakes through Annex 4. As part of the International Joint Commission (IJC) assessment duties, the IJC Science Advisory Board and Water Quality Board have organized a synthesis project with a primary goal of assessing progress through domestic action plans (DAPs) of the governments of Canada and the United States, as well as state and provincial plans, and a secondary goal of addressing nutrient-related concerns in Lake Ontario. The approach has involved an extensive review of adoption of prior IJC recommendations in DAP programs and other activities, identification of information and other needs, and collection of expert and stakeholder input through an October 2021 workshop. Draft findings include that progress to date on DAPs has been primarily programmatic, including development of new adaptive management approaches. Earlier significant progress addressing point sources has been accompanied by more recent enhancement of technical support elements including monitoring, numerical modeling, regular calculation of tributary loads, and creation of online portals. Information gaps identified include a lack of high-resolution temporal and geospatial data to determine changes in loads by sources; inadequate data on adoption of best management practices and understanding of their effectiveness and of how to optimize incentive programs; nutrient transformation details between the edges of fields and in-lake blooms; hypoxic area and dynamics in Lake Erie; toxin concentrations across blooms; Cladophora

coverage in eastern Lake Erie and in Lake Ontario; and winter limnology and nutrient cycling in both lakes. This assessment will ultimately include recommendations to the GLWQA Parties on steps for improving programs to address nutrients in Lake Erie and Lake Ontario, including as DAPs are refined in 2023.

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CARR, W.[1], PATEL, V.[1], EIDT, E.[1], GUNJAL, S.[1], FILAS, E.[1], APUL, D.[1], KIPPENHAM, E.[2], COLLINS, R.[2], [1]University of Toledo; [2]City of Toledo. **Reducing Trash in Toledo's Waterways Using Trash Traps**.

An estimated 2,500 tons of plastic enter Lake Erie every year, and the Lower Maumee and Ottawa-Stony Watersheds are major contributors to this problem. In this project, the City of Toledo aimed to address this problem by installing trash traps at five locations in Toledo. Four kinds of trash traps were installed: Brute Bins, Seabins, Litter Gitter, and boom and net. These devices block the flow of floating litter and collect it, thus preventing it from polluting downstream waterways and Lake Erie. The samples collected from the trash traps are being categorized by the University of Toledo team using the Escaped Trash Assessment Protocol (ETAP). Preliminary data shows that styrofoam and plastic contribute the largest fraction of litter in the waterways. This presentation will discuss the sampling design and data collected from the trash traps. We will also discuss the roles and collaboration of the City of Toledo, the University of Toledo, Partners for Clean Streams, TMACOG, and Keep Toledo Lucas County Beautiful.

CHAFFIN, J.[1], WESTRICK, J.[2], FURR, E.[2], BIRBECK, J.[2], REITZ, L.[3], STANISLAWCZYK, K.[1], LI, W.[4], WEBER, P.[4], MAYALI, X.[4] BRIDGEMAN, T.[5], [1]Ohio State University; [2]Wayne State University; [3]University of Michigan; [4]Lawrence Livermore National Laboratory; [5]University of Toledo. **Microcystin production and biodegradation rates in the western basin of Lake Erie**.

Cyanobacterial biomass forecasts currently cannot predict microcystin (MC) concentration, one of the most ubiquitous cyanotoxins that threaten human and wildlife health. Mechanistic insights of how MC production and biodegradation change spatially and throughout the bloom season can help overcome the limitations that currently prevent forecasts of MC concentration at the whole lake scale. Here we studied MC production and degradation during two growth seasons (2018 and 2019) in two western Lake Erie sites, one site in Maumee Bay and the second in the center of the western basin. These two sites are commonly plagued by summer Microcystis blooms but have different physiochemical properties. MC production and biodegradation rates were quantified using the microcosm approach. MC production rates were greater with elevated nutrients than under ambient conditions and were highest near shore during the initial phases of the bloom, and production rates were lower in later bloom phases. We examined biodegradation rates of MC-LR in natural waters by the addition of extracellular 15N10-MC-LR (1 μg L-1). Extracellular MC-LR remained stable in the abiotic treatment, and adsorption onto sediments was minimal, while extracellular MC-LR decreased in all biotic treatments, suggesting biodegradation. Greatest rates of extracellular MC-LR biodegradation (-8.76 d-1) were observed during peak bloom conditions, while lower rates were observed with lower cyanobacteria biomass. Cell-specific incorporation of 15N10-MC-LR measurements by NanoSIMS showed that a small percentage of the heterotrophic bacterial community actively degraded MC-LR. Our measured bulk rates of MC production and biodegradation, combined with the microscale analysis of MC incorporation by single cells, suggest that MC predictive models could be improved by incorporating MC production and biodegradation

rates, which are influenced by cyanobacterial bloom stage (early vs. late bloom), nutrient availability, and bacterial community composition.

CHIOTTI, J.[1], METTLER, A.[1], BRIGGS, A.[2], BOASE, J.[1], DEBRUYNE, R.[3], ROSEMAN, E.[3], DROUIN, R.[4], [1]U.S. Fish and Wildlife Service; [2]Michigan Department of Natural Resources; [3]U.S. Geological Survey; [4]Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry. **Identifying and characterizing juvenile lake sturgeon (Acipenser fluvescens, Rafinesque, 1817) occupancy hot spots within the St. Clair-Detroit River System**.

Over the past two decades, extensive monitoring has been conducted in the St. Clair – Detroit River System (SCDRS) to describe spatial and temporal patterns of lake sturgeon (Acipenser fulvescens). To characterize spatial patterns in juvenile lake sturgeon (< 1,000 mm TL) based on survey collections, 'hot spots' were identified through optimized hot spot analysis (HSA). This HSA was then interpolated by inverse distance weighted analysis to determine extent of identified 'hot spots' and 'cold spots'. Additionally, habitat variables (i.e., water depth, water velocity, and dominant substrate type) were investigated using a single season occupancy model to determine their influence on juvenile lake sturgeon occupancy probability. In total, 1,203 juvenile lake sturgeon were captured across 4,197 surveys. Three unique 'hot spots' were identified; western Lake Erie, Fighting Island in the Detroit River, and the North Channel in the St. Clair River. Interpolated 'hot spots' encompassed 73.1 km² in western Lake Erie, 4.7 km² near Fighting Island, and 6.6 km² in the North Channel. Detection probabilities within hot spots ranged from 8.8 – 43.4%. No habitat variables significantly predicted juvenile lake sturgeon occupancy. Juvenile lake sturgeon were captured in western Lake Erie where the water depth was > 5.1 m and odds of occupancy increased with increased water velocity. Juvenile lake sturgeon in the Detroit and St. Clair River 'hot spots' were captured at sites with mean benthic water velocities ranging from 0.20 – 0.60 m/s and where water depth was > 7.3 m. Irrespective of waterbody, 69% of all juveniles were detected over dominant sand and gravel substrates. These results provide valuable insight about juvenile habitat use that can help managers formulate effective conservation and restoration strategies supporting the continued recovery of Great Lakes lake sturgeon.

CIBOROWSKI, J., IVES, J., WANG, L., University of Windsor. **Time Trends in L. Erie Zoobenthic Tolerance Scores - 2004-2016**.

Multiagency zoobenthic data were summarized from sampling programs comprising the Lake Erie Comprehensive Collaborative Survey initiatives of 2004, 2010, and 2014-16 and compared with surveys of the 1970s and 1990s. Identity, abundance and biomass of invertebrates collected in Ponar grabs from over 700 sites were compiled. Scores for each taxon representing tolerance to eutrophication or hypoxia were compiled from the literature representing a 10-point scale (0 = minimally tolerant; 10 = maximally tolerant). A tolerance value for each sample was calculated by multiplying numbers (or biomass) of individuals of each taxon by its tolerance score and calculating a weighted mean. Benchmark values distinguishing classes of tolerance-value based condition were assigned at breakpoints in the frequency distribution of sample values. Data were compared across time points for the western and central basins combined. In 2004, sample sites ranged in condition from Mesotrophic-Good (<7) to Very Eutrophic-Poor (>9) throughout the Western and Central basins. Sites in the southern portion of western L. Erie were predominantly in Poor or Fair condition (8-10), whereas sites distant from shore in the Western basin's northern portion tended to exhibit Mesotrophic-Good scores (6-7). Fewer western basin sites were sampled in 2010, but overall condition appeared to have improved in comparison to 2004. Most of the sites classified as Mesotrophic-Fair (7-8) occurred near the Canadian shoreline or near Pelee Island. Overall condition in 2015 appeared to be better (i.e., have equivalent or lower scores than were observed in 2010). In

2010, benthos at most stations (71±8% of 34 sites) were classified as Mesotrophic-Good (5-7). In 2015, 33 of 38 sites assessed (87±5%) were classified as Mesotrophic-Good.

CIBOROWSKI, J.[1], KOVALENKO, K.[2], ANGRADI, T.[3], BARR, L.[1], BARTON, D.[4], BRADY, V.[2], CAI, M.[2], KREIGER, K.[5], MANCINI, E.[1], SMITH; S.[6], ALLAN J.[6], WANG, L.[1], JOHNSON, L.[2], [1]University of Windsor; [2]University of Minnesota, Duluth; [3]U.S. Environmental Protection Agency; [4]University of Waterloo; [5]Heidelberg University; [6]University of Michigan. **A Zoobenthic Index of the Condition of Lake Erie**.

A challenge of developing and calibrating indicators using the Reference Condition Approach is to suitably define the boundary of the reference condition within which to sample and against which to assess test sites. Alternatively, one can calibrate indices by sampling across the full range of environmental stress, ordinate effects (response) variables against the gradient and identify the changing range of variations in the response variables. We created a composite stressor gradient for Lake Erie by combining a suite of consensus-derived Great Lakes Environmental Assessment and Mapping (GLEAM) stress measures likely to influence zoobenthos. We then examined variation in zoobenthic composition from four datasets - Erie Comprehensive Collaborative Studies of 2004, 2010 and 2014-16 (ECCS; benthos from 590 stratified-randomly located stations), EPA's 2010 National Coastal Condition Assessment (40 nearshore stations) and . We performed Threshold Indicator Analysis (TITAN) for benthic invertebrates to infer a reference/nonreference stress gradient threshold. Subsequently, a provisional habitat-specific (depth, substrate) benthic composite index was derived, relating changing community composition to the stress gradient. Community composition from an archival dataset collected between 1973-75 (Herdendorf 1980) was used to infer zoobenthos in the degraded condition. Hexagenia mayflies, gammarid amphipods, and oligochaete species/chironomid genera characterized the reference condition of shallow-soft (western basin), shallow-hard, and deep-soft habitat locations, respectively. Degraded communities were almost completely dominated by other oligochaete species and chironomid genera. Validation using data from 2010 and 2014-16 surveys broadly confirmed these associations.

COLLINGSWORTH, P., Purdue University. **Overview of Lake Erie CSMI activities in 2019**.

The binational Cooperative Science and Monitoring Initiative (CSMI) under Annex 10 (Science Annex) of the Great Lakes Water Quality Agreement coordinates agency science and monitoring in support of management of the Great Lakes ecosystem. The process includes enhanced monitoring and science-based field activities which are conducted in one Great Lake per year and tied to the information needs identified by the Lake Partnerships. The 2019 Lake Erie CSMI investigations by federal agencies and partners addressed key knowledge gaps among five broad themes including watershed-based studies to address eutrophication, in-lake efforts to studies eutrophication, research to address the changing food web, research to address contaminants and studies to address beach closings. Here, we will provide an overview of the CSMI five-year cycle that involves the development of science priorities, field year planning, intensive field year science and monitoring, analysis and reporting to decision-makers. Highlights from reporting and outreach efforts on other lakes are also discussed.

COLLIS, L.[1], PETERS, D.[1], SHAW, M.[1], SLAGLE, Z.[2], VANDERPLOEG, H.A.[3], HOOD, J.M.[1], [1]The Ohio State University; [2]Ohio Department of Natural Resources; [3]NOAA Great Lakes Environmental Research Laboratory. **Grazing by Meso- and Microzooplankton During Harmful Algal Blooms in western Lake Erie**.

The western basin of Lake Erie (WBLE) has experienced a reemergence of cyanobacterial harmful algal blooms (cHABs), with significant socioeconomic and ecological consequences.

However, the effect of cHABs on aquatic food webs remain poorly understood, in part, due to limited information on zooplankton grazing of cyanobacteria and other phytoplankton groups. Zooplankton can shape phytoplankton community dynamics and structure through selective grazing on specific groups and serve as a key energetic link between primary producers and higher trophic levels such as fish. To better understand how cyanobacteria influence zooplankton grazing rates and selectivity, we measured meso- (>200 µm) and microzooplankton (<200 µm) grazing on cyanobacteria, green algae, diatoms, and cryptophytes monthly during April-June and biweekly during July-October in the WBLE. We conducted gradient-grazer and dilution assays (Landry and Hassett 1982, Lehman and Sandgren 1985, Hambright et al. 2007) wherein we incubated meso- and microzooplankton for 24-hours at varying densities and measured phytoplankton composition and abundance pre- and post-incubation with a fluoroprobe to estimate grazing rates and selectivity for each phytoplankton group. Zooplankton grazing rates were low overall, particularly during the spring when zooplankton densities were low. During cyanobacteria blooms, mesozooplankton grazed primarily on cyanobacteria, but also selected for diatoms. In contrast, microzooplankton grazing on cyanobacteria was limited and selected for green algae and cryptophytes. By providing rare empirical estimates of zooplankton grazing rates in WBLE, our results will further our understanding of zooplankton dynamics and energy flow in this large lake ecosystem, enhancing our ability to predict how food webs and ecosystem-level processes are influenced by cHABs.

CROSS, M., MAYER, J., BEKKER, K., The Toledo Zoo and Aquarium. **Estimating population size of a threatened turtle using community and citizen science**.

Blanding's turtles (Emydoidea blandingii) are considered threatened or endangered throughout most of their range. A critical step in determining appropriate conservation actions for this species is assessing the status of remaining populations. The long-term surveys required to adequately document population trends are lacking, as they are generally labor-intensive and time-consuming. We used community and citizen science–collected data and free pattern-recognition software to conduct a mark–recapture study on female Blanding's turtles in a northwest Ohio wetland. Over a 5-yr period, community and citizen scientists gathered 155 images of 65 individual female Blanding's turtles. Our results suggest the wetland has a population of 87 (95% CI = 74–116; SE = 10.1) adult female Blanding's turtles. Deriving preliminary population estimates from photographic recapture data is an example of how the efforts of community and citizen scientists can benefit ongoing research projects and conservation efforts.

CURRIE, W.[1], BOWEN, K.[1], DOVE, A.[2], FITZPATRICK, M.[1], NIBLOCK, H.[1], MUNAWAR, M.[1], ROZON, R.[1], [1]Fisheries and Oceans Canada; [2]Environment and Climate Change Canada. **Findings from the whole-lake lower trophic food web survey for the 2019 Erie CSMI**.

As part of the 2019 binational Cooperative Science and Monitoring Initiative (CSMI) field year for Lake Erie, scientists from Fisheries and Oceans Canada and Environment and Climate Change Canada undertook a late July comprehensive whole lake (nearshore and offshore) planktonic food web study of the productivity gradient from turbid hypereutrophic in the west to clear oligotrophic in the east. The Lake Erie ecosystem is well known to be impacted by harmful algal blooms (HABs) and hypoxia driven by nutrient loads from major tributaries, resulting in a very strong primary productivity gradient, 4-18x higher in the western basin. Productivity is dominated by larger phytoplankton primarily from the cyanobacteria Microcystis (but also Pseudoanabaena and Aphanocapsa) and Diatoms, and elevated bacterial growth rates. Chlorophytes dominated in the central basin and Chrysophytes dominate in the east. Phytoplankton biomass follows the same gradient with 27x higher algal biomass in the west. The pattern of zooplankton biomass is similar to phytoplankton, though not of the same magnitude being 2x higher, and highly variable in the

western basin. Biomass is dominated by Daphnia, with smaller percentages of cyclopoid copepods and veligers of Dreissena. The deeper central and eastern basins still had a large percentage of Daphnia, but much higher percentages of calanoid copepods. Zooplankton biomass is almost 2x offshore compared to nearshore in the central and east. The eastern basin notably has extremely low zooplankton biomass in the hypolimnion. The middle section of the central basin has depressed zooplankton biomass, but higher relative biomass in the meta-hypolimnion zone even though there is habitat constriction by hypoxia. The difference in the magnitude of gradients between basins for ratios of zooplankton to phytoplankton biomass will be discussed with implications for trophic efficiency and fisheries productivity, and utility to other projects which are part of this large collaborative program.

CUTRELL, G.[1], VERHAMME, E.[1], JOHNSON, L.[2], HOLST, E.[3], [1]LimnoTech; [2]Heidelberg; [3]Cleveland Water Alliance. **Evaluation of Edge-of-Field Nitrate Sensors in the Maumee River Basin, OH**.

Nutrient loads play a key role in the proliferation of harmful algal blooms (HABs), and the ability to quantify nutrient loads at edge-of-field helps to enable the predictive of modeling HABs. As state and federal agencies amplify their focus on tracking phosphorus and nitrogen from agricultural lands, an interest in edge-of-field monitoring devices that can continuously monitor nitrates autonomously and in real-time is expanding throughout the Lake Erie watershed to help quantify nutrient loads and support cost-share projects to help farmers reduce nutrient loss from farmland into streams. To evaluate new and emerging sensor technologies coming to market for monitoring and quantifying nutrient loads, a study was conducted in 2021. The site, selected through the Cleveland Water Alliance Testbed Program, was within the Maumee River Basin, OH, co-located at a National Center for Water Quality Research (NCWQR) Tributary Loading Program monitoring location. The study site was located along a small edge-of-field stream within a farmland watershed. During the study, NCWQR used an autonomous water sampler to collect samples twice a day. The outcomes of this study will be presented, including laboratory-analyzed nitrate results compared against a wet chemistry-based analyzer from Green Eye Science (NuLAB), and two ultraviolet based sensors from YSI (EXO NitraLED) and OTT HydroMet (ecoN). Performance, cost, and trade-offs between sensors will also be addressed.

D

DANIEL, S.[1], BURLAKOVA, L.[1], KARATAYEV, A.[1], PORTO-HANNES, I.[1], HEBERT, P.[2], PFRENDER, M.[3], LODGE, D.[4], RUDSTAM, L.[4], TREBITZ, A.[5], WESTERGAARD, S.[5], [1]SUNY Buffalo; [2]University of Guelph; [3]University of Notre Dame; [4]Cornell University; [5]U.S. Environmental Protection Agency. **Challenges to DNA barcoding: an ecologist's perspective**.

In recent years there has been a drive to develop a genetic barcode library to increase the scope of diversity surveys and detection of aquatic species compared with traditional sampling approaches. While providing useful information, there are still potential and significant obstacles with the use of genetic barcoding as a means of taxonomic identification and species surveillance. The Great Lakes Center at SUNY Buffalo State has expanded the taxonomic coverage by adding 153 species to The Barcode of Life Database (BOLD) DNA library; however, as this project ends, we consider it is necessary to share some of the more challenging aspects of developing a DNA library, and the subsequent use of that library. The ultimate success of a usable reference genetic barcode (sequence from one gene region, commonly mitochondrial Cytochrome c Oxidase I, COI) depends on several factors including preservation methods, taxonomic group, functional feeding

group, and method of taxonomic identification which all may impact the rate of failure to amplify DNA, instances of high sequence variability, and/or the instance of cryptic taxa. In some groups, namely Pleuroceridae snails, a single reference barcode (i.e., use of a single gene) is particularly difficult to distinguish among species and may require the use of multiple barcodes or sequencing of the whole genome. This presentation discusses difficulties in genetic barcoding and proposes suggestions moving forward for understudied invertebrate phyla in the Great Lakes. Additionally, we will discuss the development of a Great Lakes DNA Reference Library containing barcodes from nearly all major invertebrate taxonomic groups within the region.

DAWES, J., The Commons. **Supporting the Smart Citizen Community Science Program with Interoperable Data**.

The Great Lakes One Water (GLOW) Smart Citizen Initiative supports the collection and analysis of water quality data by local community science programs. These monitoring programs drive the collection of baseline and discrete water quality monitoring data to have a real-time pulse on the health of their local waters. Through their Smart Citizen Science Initiative (SCSI), Cleveland Water Alliance is working to overhaul fragmentation to unify these citizen-driven avenues of data collection across the Lake Erie region, connecting local water quality conditions, threats, and restorative action to decision makers and the general public in a way that enables data-driven action. CWA focused on offering participants standardized data management protocols and systems. This approach not only created an easier pathway to participation but was also integral to the success of the SCSI program goals. The digitization of discrete datasets put in place standard systems to aid efforts to democratize data. The ability to easily integrate functionality from a variety of third party applications is a critical component of both collaborative water quality monitoring programs and modern software development. For monitoring programs, data interoperability enables data collectors, aggregators, and consumers to work collectively to distribute and achieve data-driven decisions. Data interoperability also enables developers to focus on creating technology that fits their expertise while piggybacking on functionality, data, and user communities established in other complementary efforts. Data management has been the linchpin for SCSI program's intersectionality goals. Through use of The Commons's Water Reporter platform, Champions retain their own monitoring program integrity and analysis while simultaneously porting their digitized data sources to participate in aggregated analysis and decision-making. The platform equips the consortium of Champions to share their machine readable data via their own websites, to state agency databases, and to a public-facing SCSI map application. The portability of data and streamlined data management allow all participants to spend more time in the field or responding to data insights rather than transcribing paper form data or scrubbing spreadsheets.

DEBRUYNE, R.[1], TUCKER, T.[1], IRELAND, S.[1], BOWSER, D.[1], PROVO, S.[2], EATON, L.[2], MAYER, C.[2], KENNEDY, G.[1], KEELER, K.[1], BRIGGS, A.[3], PRITT, J.[4], ROSEMAN, E.[1], [1]U.S. Geological Survey; [2] University of Toledo; [3]Michigan Department of Natural Resources; [4]Ohio Department of Natural Resources. **What we know from 15 years of ichthyoplankton sampling in the St. Clair-Detroit River System**.

The St. Clair-Detroit River System has a history of environmental degradation and has undergone improvements in habitat and water quality since the 1970s. We present an overview of long-term and short-term ichthyoplankton studies to assess response of fish communities to environmental improvements. We compared ichthyoplankton community data pre- and post-remediation efforts (1977–1978 to 206-2015). Both assemblages exhibited a predictable larval fish phenology. Higher densities of larval fish were found in the Detroit River, but greater taxa richness and Shannon diversity were observed in the St. Clair River. System-wide, fourteen new taxa were

observed in the 2000s study period and relative densities of Alewife and Rainbow Smelt declined. Complementary zooplankton surveys and larval fish diet analysis show that both rivers provide suitable nursery habitat to support larval fish growth and survival. There was intensive sampling in 2018 and 2019 to examine larval Yellow Perch spatial and temporal dynamics in Lake St. Clair and the lower Detroit River. Significant larval density hot spots were present in Mitchell's and Anchor Bays coinciding with high levels of submerged aquatic vegetation and earlier temperature increases. These two areas are likely providing habitat to increase survival and growth through mid-summer. High connectivity in larval presence was found between Lake St. Clair and lower Detroit River. Finally, we found immediate and continued evidence of spawning and successful hatching of Lake Sturgeon from recently constructed artificial reefs. Higher densities of larvae drifted at night near the river bottom. Our combined results indicate that improved environmental and habitat conditions in the system likely contributed to increased larval fish richness, decreased densities of nonnative taxa, and restoration of functional spawning habitat for Lake Sturgeon. Further, these results demonstrate a strong return on investments in habitat restoration and water quality improvements.

DENBOW, T., WHITEHEART, R., HOEHNE, S., Biohabitats. **H2Ohio Sandusky Bay Restoration Initiative Nutrient Reduction Wetlands – Design Elevations using the Twin Limit Marsh Model**.

The Sandusky Bay Restoration Initiative, launched by the ODNR Office of Coastal Management, was launched to implement much-needed landscape-scale restoration to enhance nutrient assimilation benefits of restored and created wetlands in the Bay. Development of the design required understanding of existing conditions in the Bay caused by years of nutrient loadings from the Sandusky River and other tributaries. Most of the existing wetlands in the Bay are associated with diked wetlands that attract waterfowl and support hunting. While some diked wetlands provide water quality benefits, ecological functions are restricted due to the lack of connection to the open waters of the Bay. Also, dikes have created a hardened the shoreline, increasing nearshore wave energy dynamics. In response, opportunities for restoring wetlands require innovative approaches to re-establish wetland functions. H2Ohio Nutrient Reduction wetlands focus on reversing the Bay's problems by using a combination of nature-based shoreline, riparian floodplain, and in-bay shoals restoration projects. This talk focuses on one crucial design element, establishing design grades for wetland creation given seasonal, short-term, and long-term water elevations changes in the Bay and Lake Erie. Using the Twin Limit Marsh Model developed by Keddy and Campbell (2020), Biohabitats will discuss why the model was selected for setting design elevations and provide insights into how the design elevations are combined with other habitat features, to establish robust and resilient designs to achieve restoration goals. Keddy, P.A. and D. Campbell. 2020. The Twin Limit Marsh Model: A Non-equilibrium Approach to Predicting Marsh Vegetation on Shorelines and in Floodplains. Wetlands 40:667-680.

DIESING, E., Clinton River Watershed Council. **Clinton River Citizen Science**.

The Clinton River Watershed Council has entered into partnership with the Cleveland Water Alliance on a joint project to expand the reach of citizen science efforts and data accuracy. We will discuss our past efforts and future endeavors in the realm of community engagement and data collection.

DROUILLARD, K., University of Windsor. **Fish movements confound beneficial use impairments #1 - fish consumption advisories**.

Several Great Lakes Areas of Concern (AOCs) continue to be impaired for beneficial use impairment (BUI) #1: fish and wildlife consumption advisories leading to delays in the AOC

delisting. The Detroit River AOC identifies walleye as one of the indicator species on which BUI #1 is assessed. Here, we present an assessment of fish chemical signatures in the Detroit River walleye as contrasted against chemical signatures in walleye collected from Lake St. Clair and western Lake Erie. Data were derived from Ontario's Sportfish Monitoring Program and equivalent Michigan fish contaminant monitoring datasets. A discriminant functions model was trained using 389 fish captured from Canadian and US jurisdictions of western Lake Erie or Lake St Clair and was able to successfully categorized 85.6% of fish to their correct location of capture. The trained model was then used to categorize Detroit River caught fish (n=162 fish) into Lake Erie-like, Lake St. Clair-like or unknown (interpreted as Detroit River resident). Model assignment indicated only 35.8% of Detroit River caught walleye were classified as residents (i.e. unique from Lake St. Clair or Lake Erie), while 19.8% of fish were categorized as Lake St. Clair-Like and 44.4% were allocated as Lake Erie-Like. When PCB concentrations in the combined Detroit River fish were compared to walleye PCBs concentrations across all Non-AOC Great Lakes Canadian fishing zones, there was a significantly higher PCB concentration in the AOC compared to the reference. However, when fish were restricted to that determined as Detroit River residents, the PCB concentrations in resident fish were no longer significantly elevated relative to the reference. Indeed, fish designated as western Lake Erie like had higher PCBs than residents and equivalent contaminant levels as fish from western Lake Erie. These data underscore how fish movements can confound assessment of BUI#1 and should be takeninto consideration in a weight of evidence approach when addressing this BUI's delisting criteria.

DUTTA, S., LEFF, L., MOU, X., Kent State University. **Removal of pharmaceuticals and personal care products (PPCPs) using lab-scale drinking water biofilters using source water from Lake Erie watershed**.

Pharmaceuticals and personal care products (PPCPs) are a group of emerging contaminants that are released from treated wastewater effluents and agricultural runoff. Lake Erie watershed is an important drinking water source for several local drinking water plants and has been found to contain many PPCPs in one of our past studies. Biofiltration is part of the drinking water treatment process which has been suggested as a cost-effective and sustainable way to remove some PPCPs. However, the efficiencies of biofiltration in removing individual PPCPs and the underlying mechanisms remain unclear. The specific objectives of this study were (1) to investigate the extent to which PPCPs can be biologically removed from the lab-based active filters and (2) to examine the effects of PPCPs on microbial community structure in lab-based biofilters. We simulated the biofiltration units of the Akron drinking water treatment plant (DWTP) by using chromatography columns that had been layered with gravels, sands, and anthracite according to the biofilter set up. These columns were then fed with water from Lake Rockwell, the source water of Akron DWTP. After 30 days of priming, 17 beta-estradiol, carbamazepine, and cotinine (1000 ng/L) were run through the column through gravity, effluents from the columns were collected and analyzed using HPLC-MS to measure PPCP removal every 7 days for a total of 28 days in total. Carbamazepine showed the highest removal efficiency with a degradation rate of 14 ng/L. followed by cotinine (28.73ng/L) and estradiol (47.19 ng/L). Degradation products and intermediates of the targeted PPCPs, such as 10,11 dihydroxycarbamazepine (from carbamazepine), and estriol and 17 alpha estradiol (from 17 alpha estradiol) were observed in the effluents.

E

EATON, L.[1], DEBRUYNE, R[2]., KRAUS, R.[2], ROSEMAN, E.[2], EDWARDS, W.[2], [1]University of Toledo; [2]United States Geological Survey. **Zooplankton Community Dynamics in the Central Basin of Lake Erie**.

The Lower Trophic Level Assessment program was established in 1999 by the Forage Task Group to monitor and assess factors influencing Lake Erie fisheries. The Forage Task group is charged with maintaining mesotrophic conditions that favor percids in the central basin of Lake Erie. Zooplankton community changes can impact larval and planktivorous fish because both rely on zooplankton as a primary food source. Samples of zooplankton have been collected every two weeks from May to September at 18 stations across Lake Erie, and our dataset includes samples from 1999-2011. This project focuses on zooplankton community trends from two sites in the central basin at 5 m and 14 m deep. Rotifers and dreissenid mussel veligers had the highest average density (number/liter) and biomass (µg/L) in most years. Species richness ranged from a low of 18 in 2003 to a high of 28 in 2009. When looking at the larger groups of organisms, cladocerans made up most of the density in all years except for 2000 and 2009 when it was cyclopoid copepods. Cladocerans made up most of the average biomass among the larger groups in 2002 and 2003, then calanoid copepods dominated in 2009. Monthly density peaked in June and July, and the most common taxa were rotifers, veligers, copepod nauplii, and cladocerans. A ratio of calanoids to cladocerans plus cyclopoids was taken to provide a general indication trophic status at these sites, and this ratio was lower indicating more eutrophic conditions compared to historic data, however our sites were located more nearshore than the historic sites. Our two sites are in the transition zone between the eutrophic western basin and the mesotrophic central basin, and they appear to indicate how the lake is shifting in space and time between those two trophic states.

ELGIN, A.[1], GLYSHAW, P.[1], CAMILLERI, A.[2], [1]NOAA Great Lakes Environmental Research Laboratory; [2]Cooperative Institute for Great Lakes Research. **Dreissenid mussels in Lake Erie: Population assessment, body condition, and reproductive status**.

Long-term monitoring of invasive dreissenid mussels in Lake Erie has revealed dramatic population changes over time. Zebra mussels expanded early and were then largely displaced by quagga mussels. Current population numbers are below the peak densities observed in the 1990's and 2000's, but dreissenids remain the dominant benthic species and their impacts are still realized. We collaborated with the USGS in 2019 to conduct their long-term mayfly and dreissenid mussel survey at 30 stations in western Lake Erie. We also assessed quagga mussel body condition (relative tissue mass for a given length) and reproductive status at up to nine stations across Lake Erie, most of which were collected during the CSMI Whole Lake Benthic Survey on board the EPA R/V Lake Guardian. Total dreissenid biomass averaged 214 g/m2 (whole mussel wet weight), but 67% of the stations had densities < 50 g/m2. Quagga mussels were the more prevalent dreissenid species, accounting for 80% of total dreissenid density. Body condition was highest at the <30 m sites, intermediate at a >50 m site, and lowest at the 31-50 m sites. Most mussels had ripe gametes in early July, however a few had already spawned by this time. Improving our ability to describe dreissenid mussel biology and population dynamics is important for anticipating current and future changes caused by this highly impactful species.

F

FARVER, J., Bowling Green State University. **Copper and Zinc in Boat Wash Wastewater from Lake Erie Marinas**.

Fouling of boat bottoms by aquatic organisms increases frictional drag on boats resulting in reduced speed, greater fuel consumption, and poorer maneuverability. Antifoulant paints employed to prevent this typically contain very high levels of copper and/or zinc which, when boat bottoms are cleaned, can be released into the environment and ultimately into lakes where they can become harmful to aquatic life. As such, per USEPA regulations, boat wash wastewaters cannot be disposed directly to public waterways. With funding from the Lake Erie Protection Fund, researchers at Bowling Green State University in collaboration with the Ohio Clean Marinas program and Lake Erie marina operators worked to establish the amounts of Cu and Zn generated by boat washing and to evaluate ways to treat the wastewaters for proper disposal. The results show powerwashing of boat bottoms can result in highly elevated Cu and Zn contents in wastewaters (up to 281 ppm Cu and 68 ppm Zn) and surrounding sediments (up to 504,200 ppm Cu and 16,020 ppm Zn). Further, the amount of Cu and Zn in the wastewaters relates to the amount in the paint used on the boat,. In addition, the amount of Cu and Zn present in suspended particles of paint chips is significantly greater than the amount dissolved in the wastewater. Disposal of wastewaters to a sanitary sewer system after some on-site treatment may be the most cost-effective method for marinas. Results of this study show that a combination of on-site gravity settling and filtration treatments can greatly reduce the amount of Cu and Zn in the wastewater, to levels that are near to or below the allowable limits of 2.4 ppm Cu and 3.3 ppm Zn for disposal to sanitary sewers as set by the State of Washington. Currently there are no Ohio regulations on allowable limits for disposal of boat wash wastewaters to a sanitary sewer system.

FIGARY, S.[1], BARBIERO, R.[2], HOOD, J.[3], KANE, D.[4], LUDSIN, S.[3], RUDSTAM, L.[1] WATKINS, J.[1], WINSLOW, C.[3], [1]Cornell University; [2]GDIT; [3]Ohio State University; [4]Heidelberg University. **Using zooplankton to track ecosystem condition in Lake Erie**.

Zooplankton are a major conduit of energy from phytoplankton to fish due to their intermediate position in the food web and have been suggested as ecosystem indicators for both top-down and bottom-up processes. In the summer of 2021, a zooplankton working group was developed with members from the Ohio Environmental Protection Agency (Ohio EPA), Ohio State University, Cornell University, Heidelberg University, Ohio Sea Grant, and others. The purpose of the working group was to provide expertise to the Ohio EPA as they develop biological criteria for tracking ecosystem health in the western and central basins of Lake Erie. Many possible trophic status and fish predation indicators were considered and investigated using USEPAs Great Lakes National Program Office data from 1997-2019 and Lake Erie Plankton Abundance Study (LEPAS) data. Overall, percent calanoids by biomass was the best indicator of trophic status in both basins and across all five Great Lakes. GLNPO analysis included ten sites in the central and six in the wester basins and found high inter-site variability in both basins, which should be taken into consideration for site selection. The group is continuing to explore potential indicators for fish predation such as the ratio of large to small Daphnia or overall zooplankton size. After specific indicators are chosen, the group will develop a scoring rubric to translate the indicator scores to the ecosystem condition of each basin. While still early in this analysis, this approach has shown the importance of long-term datasets for developing ecosystem indicators.

FISCHER, J.[1], CHIOTTI, J., BOASE, J.[1], DROUIN, R.[2], ROSEMAN, E.[3], WILLS, T.[4], [1]U.S. Fish and Wildlife Service; [2]Ontario Ministry of Natural Resources; [3]U.S. Geological Survey; [4]Michigan Department of Natural Resources. **Assessing the Assessment: Long-Term Fisheries Monitoring in the St. Clair-Detroit River System**.

Long-term monitoring provides natural resource managers valuable information on system and species trends; however, effective monitoring requires sampling methods and effort with enough precision and accuracy to track trends through time. To evaluate a gillnet monitoring program in the St. Clair-Detroit River System (SCDRS), we conducted a simulation study assessing the program's ability to track catch-per-unit-effort (CPUE) with varying levels of sampling effort (1, 5, 10, and 25 samples per monitoring zone) and six underlying CPUE trends (0.5, 0.9, 1, 1.1, 1.5, and 2 fold increases) for three fish species of management interest (Walleye Sander vitreus, Redhorse spp. Moxostoma spp., and White Sucker Catostomus commersonii). Autoregressive models of the first order (AR(1)) were used to account for temporal correlation in CPUE and CPUE across species and locations was assumed exchangeable. Relative bias (RB), coefficient of variation (CV), and coverage were used to assess the accuracy and precision of estimated CPUE at annual time-steps and for five-year running means. All performance metrics became less variable as sampling effort increased, with estimates becoming less biased, more precise, and having increased coverage. Underlying CPUE trends had little influence on RB and coverage, but CV decreased as the underlying trend in CPUE increased. At mean annual sampling effort (10 sites per zone per year), the estimated CPUE for five-year running means were less biased and more precise than the annual estimates. Confidence in the estimated five-year running mean CPUE was slightly overoptimistic, as coverage ranged from 89-94% (ideal coverage was 95%). However, RB of the estimates at mean sampling effort was less than 10% for five of the six underlying trends, indicating low bias. Therefore, gillnet assessments can reliably monitor adult fish CPUE in the SCDRS, with a realistic amount of effort, particularly when inference is based on five year running means.

FITE, K.[1], MANUBOLU, M.[1], BUDNIK, R.[1], BUSCH, K.[2], HARRIS, C.[1], KULASA, M.[1], BOLGRIEN, D.[3], BOWEN, K.[4], COLLINGSWORTH, P.[5], COTTER, A.[3], CURRIE, W.[4], HOFFMAN, J.[3], HOOD, J.[1], JICHA, T.[3], FITZPATRICK, M.[4], MUNAWAR, M.[4], NIBLOCK, H.[4], RUDSTAM, L.[6], WATKINS, J.[6], LUDSIN, S.[1], [1]The Ohio State University; [2]Miami University; [3]U.S. Environmental Protection Agency; [4]Fisheries and Oceans Canada; [5]Purdue University/Illinois-Indiana Sea Grant; [6]Cornell University. **Understanding microcystin accumulation in Lake Erie's food web**.

Harmful algal blooms (HABs) have negatively affected aquatic ecosystems worldwide by increasing hypoxic zones, reducing water clarity, and contaminating water supplies and harvestable fish with cyanotoxins. One such toxin, microcystin, is a potent liver toxin that has become especially common in freshwater lakes dominated by Microcystis aeruginosa. Its prevalence is concerning to fishery management and health agencies because microcystin can accumulate at high levels in animal tissues, potentially harming the health of those animals and their consumers (including humans). Unfortunately, our understanding of how microcystin accumulates in most food webs remains limited, especially in Lake Erie, where nutrient pollution and climate change have caused HABs to resurge during recent decades. Toward helping agencies better understand microcystin accumulation in western Lake Erie's food web, we measured this toxin in water, zooplankton, and planktivorous, omnivorous, and piscivorous fishes collected during summer 2019 inside and outside of HABs. In addition to predicting that fish microcystin levels would be higher inside of HABs relative to outside, we hypothesized that phytoplanktivorous/detritivorous species (e.g., gizzard shad Dorosoma cepedianum) would have the highest microcystin levels, zooplanktivorous, benthivorous, and omnivorous species (Notropis spp. and white perch Morone americana and yellow perch Perca

flavescens) would have intermediate microcystin levels, and piscivorous species (e.g., walleye Sander vitreus) would have the lowest microcystin levels. As expected, microcystin was higher in all species captured inside of HABs dominated by Microcystis compared to outside. However, our predictions based on foraging guilds were only partially supported; gizzard shad had the highest microcystin levels as expected, whereas walleye microcystin levels were like those found in all other species. In addition to helping explain our findings, we discuss their implications to agencies seeking to understand the health risks that HABs pose to Lake Erie's fish populations and fish consumers.

FITZPATRICK, M., BOWEN, K., NIBLOCK., H., PICZAK, M., MUNAWAR, M., CURRIE, W., Fisheries and Oceans Canada. **An ecological assessment of phytoplankton, zooplankton and microbial communities in the Detroit River Area of Concern**.

A comprehensive assessment of the microbial – planktonic communities of the Canadian waters of the Detroit River was undertaken during May, July, September and November of 2019. The assessment included bacteria, picoplankton, phytoplankton, heterotrophic nanoflagellates, ciliates and zooplankton. The study was designed to capture both upstream – downstream and nearshore – offshore gradients. Biomass of each component was low and typical of an oligotrophic environment. Zooplankton biomass showed a significant attenuation from upstream to downstream and phytoplankton biomass was found to be higher in nearshore waters compared to offshore. Primary productivity experiments conducted under optimal (lab) conditions was higher than expected for an oligotrophic system (avg: 8 mg C/m3/h) and suggests that the river supports viable phytoplankton assemblages. Our assessment of the organic carbon pool showed that, despite the low overall amount (50 – 100 mg C/m3 on average), the food web was still predominantly autotrophic and not bound up in heterotrophic microbes. A comparison of these results with other habitats of the Great Lakes will be made and the implications for the Remedial Action Plan will be discussed.

FOOSE, M., Michigan Department of Environment, Great Lakes, and Energy. **Contaminated Sediments of the Detroit River Area of Concern**.

The industrial development of the Detroit River shoreline on the American side has left a legacy of significant contamination in the sediments of the river. From saw mills and boat building operations to pharmaceutical manufacturing, steels mills, and automotive plants, the industries of the River were and are as varied as the contaminants that remain. The Environmental Protection Agency (EPA) and the Michigan Department of Environment, Great Lakes, and Energy (EGLE) have been working closely with the local Public Advisory Council (PAC) in an effort to determine the nature and extent of the sediment contamination and the appropriate means of remediation. Work on the sediments began in 1997 with a clean-up at Monguagon Creek, followed by remediation at Connor Creek in 2003, and the very first Great Lakes Legacy Act project at Detroit's "Black Lagoon". The next phase of planning began in 2012 with a project led by the Detroit River PAC to gather all available sediment data in the river, and since then work has been constant with the entire shoreline characterized between 2014 and 2018. Most recently, a project was completed to remediate sediments near the now-demolished Uniroyal plant in the Upper River. Other projects are in the planning stages in the Upper Trenton Channel, at the confluence of Monguagon Creek, and at the planned Ralph C. Wilson Centennial Park. This presentation will include an overview of all the work completed and planned to remediate the sediments and ultimately delist the Detroit River as an Area of Concern.

FOOSE, M., Michigan Environment, Great Lakes, and Energy. **Habitat Restoration in the Detroit River Area of Concern**.

In 2014, the Detroit River Public Advisory Council finalized the plan to remove the Loss of Fish and Wildlife Habitat and Degradation of Fish and Wildlife Populations Beneficial Use Impairments (BUI). The plan included a list of sixteen projects to be implemented throughout the river and included projects to create wetland on Belle Isle; restore island shoals at Hennepin Marsh, Stony Island, Celeron Island, provide protection and habitat off shore of Sugar Island; restore a wet-mesic flatwoods forest on Belle Isle; and build three fish spawning reefs. These projects collectively will provide habitat for native game and non-game fish, resident and migratory birds, reptiles and amphibians, and pollinators. Since finalization of the list, there has been constant planning, design, and construction of these projects including multiple local, state, and federal partners. To date, twelve of the fourteen habitat restoration projects are complete, three are currently in construction, and the final project is in design. With the construction of the final project anticipated in 2023, we are expecting to be able to remove the Habitat and Populations BUIs by 2025, a considerable feat considering the historic losses of habitat in the Detroit River system. The presentation will provide an overview of the fourteen habitat projects and include details and imagery of each.

G

GALLOWAY, A., University of Guelph. **Predicting Dreissenid Mussel Abundance in Nearshore Waters using Underwater Imagery and Deep Learning**.

Accurate and cost-effective dreissenid mussel abundance maps are vital to assess their ecological roles in aquatic systems. A deep neural network (DNN) modeling framework using semantic segmentation was developed to automatically assess the abundance distribution of two invasive mussel species Zebra and Quagga. DNN models were trained on images captured in Lake Erie and Lake Ontario using an underwater colour imaging technique. The accuracy of the method was assessed relative to manual laboratory counts of harvested mussels, their dry biomass, as well as live coverage estimated from fixed-size quadrats. Assessments performed on a test set collected from 2016–2018 show that DNN-based mussel coverage predictions explain 79% of the variance in log biomass, and 71% for log abundance (N=125). For reference, live coverage estimated by Scuba divers was transformed and found to be a better predictor of biomass (93%) and abundance (91%) (N=725), leaving room for improvement of our automated method. When identical images were presented to eight human analysts and the DNN, the agreement in live mussel coverage prediction was 85% (N=189). Models generalize well to diverse underwater illuminations, camera orientations, and resolutions, but are adversely impacted by occluding vegetation and suspended sediment. DNN models are an efficient and accurate solution for mapping mussel abundances at a scale that was previously impossible. The method may be integrated with other studies to assess the mussels' impacts in a variety of aquatic ecosystems. Source code: https://github.com/AngusG/deep-learning-dreissenid and data https://doi.org/10.5683/SP3/MZEBOJ for reproducing our method are publicly available.

GARRITY, L., Ohio Lake Erie Commission. **Delisting Progress in Ohio's Areas of Concern**.

Ohio's four Areas of Concern (AOCs) were designated as part of the Great Lakes Water Quality Agreement and continue to move closer towards their goals of being delisted as part of restoring and improving Lake Erie's watershed. The Ohio AOC Program, through the Ohio Lake Erie Commission, will provide a historical overview of the Ohio's AOC delisting process, current state of Ohio's AOCs, and the plan to restore these rivers for current and future revitalization,

including the recent delisting of the Ashtabula River AOC as the first delisted AOC in Ohio. In 1987, the Great Lakes Water Quality Agreement (GLWQA) formerly identified remedial action plans for Areas of Concerns as 'a geographic area that has caused or is likely to cause impairment of beneficial use or the ability to support aquatic life'. The 2012 Agreement outlines beneficial use impairments as a 'reduction in the chemical, physical and biological integrity of the Waters of the Great Lakes'. The four AOCs in Ohio include portions of the Ashtabula, Black, Cuyahoga and Maumee rivers, their confluences, and several adjacent watersheds along the southern border of Lake Erie. Since then, Ohio EPA and the Ohio Lake Erie Commission have worked with local stakeholders, federal and state agencies and industries to identify the beneficial use impairments (BUIs), establish remedial action plans, set BUI restoration targets, and identify actions necessary to delist the AOCs in Ohio. In 2022, this approach is showing progress through the implementation of management actions, removal of beneficial use impairments, and delisting of Ohio's first AOC. Additionally, as these areas continue to improve, local economic revitalization and public access has been rediscovered along these once highly degraded areas. The work that remains for these AOCs is based upon evaluation of current conditions, a strategy for removal of remaining beneficial use impairments, and prioritization of projects to address the most critical components of these Areas of Concern, most notably legacy contaminated sediments and habitat alterations.

GLUCK, C., GODWIN, C., University of Michigan. **Quantification of Sediment Color Changes During Hypoxia in Lake Erie's Central Basin**.

While it is known that the color of lake sediment changes with exposure to dissolved oxygen in the water column, little has been done to quantify those color changes. We collected sediment cores from Lake Erie's central basin and incubated each core under normoxic, hypoxic, and anoxic conditions sequentially. We then used quantitative image analysis techniques to determine the relationship between dissolved oxygen and sediment color across depth in the sediment. We collected sediment profile images of the sediment cores, while simultaneously measuring dissolved oxygen, creating paired records of 24-bit RGB images and oxygen concentrations for each core. We digitally generated 1x10 mm rectangle regions of interest (ROI) at progressive depths every 1 mm up to 5 cm deep using the open access ImageJ suite to measure the RGB intensity of the pixels in each ROI for all three color channels. Using multiple regression analysis to relate the RGB values of the sediment depth and dissolved oxygen, we found that sediment color is most sensitive to prolonged exposure to anoxia. This technique shows promise as a means to evaluate sediment exposure to hypoxic conditions.

GREENE, A., MANZO, L., BIXLER, S., WALLACE, E., ALFORD, J., Ohio State University/Ohio Sea Grant. **Learn About Lake Erie... Virtually! Ohio Sea Grant/Stone Laboratory Offer Virtual Field Trips to Teachers and Students Grades 5-12**.

Ohio Sea Grant and Stone Laboratory provide a unique field trip experience for students in grades 5-12 at our biological field station in the western basin of Lake Erie. As in-person programming became nearly impossible during the pandemic, Ohio Sea Grant educators responded by developing a virtual field trip program for teachers and students in grades 5-12.
Each virtual field trip is structured around a unique standards-aligned lesson that focuses on a topic that students would normally encounter during a Stone Laboratory in-person field trip program. The virtual field trips feature rich video and photographic experiences collected by our biologists as they are conducting and demonstrating biological field work. Our "Chat with a Biologist" segment of our virtual field trip experiences serve to differentiate us from other virtual programming available to teachers and students and uniquely position us to make connections with learners during difficult times in education. As we emerge from the pandemic, our virtual field trip program will also serve to

supplement and enhance our in-person field trip programs for teachers and students by providing pre or post field trip support. The field trips will also provide an alternative experience for schools unable to make the trip to Stone Laboratory.
This session will provide a preview of our virtual experiences that are currently available to teachers as well as an outline of our future plans for additional field trips.

GUIHER, S., Toledo Metropolitan Area Council of Governments. **Connecting Communities to Lake Erie With TMACOG's Student Watershed Watch**.

The Toledo Metropolitan Area Council of Governments (TMACOG) Student Watershed Watch (SWW) has been an important NW Ohio water quality educational program for more than thirty years, during which time over 20,000 students have participated. Each fall, students in grades 5-12 sample local waterways for various chemical, biological, and physical parameters to assess water quality. Following data collection, students present results to their peers and connect with professionals in environmental fields at the Student Summit. Currently, TMACOG staff are participating in a regional effort to increase the credibility of data collected by community science programs, bringing more opportunities to local classrooms. The program is supported by a partnership of local communities and organizations, who contribute both monetarily and through staff time. TMACOG's SWW provides an example of a community science initiative that has a long history of connecting young people to Lake Erie, and a promising future of continued engagement with the public and water quality stakeholders.

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HARRIS, C.[1], BUDNIK, R.[1], BUSCH, K.[2], KULASA, M.[1], BOLGRIEN, D.[3], BOWEN, K.[4], COLLINGSWORTH, P.[5], COTTER, A.[3], CURRIE, W.[4], HOFFMAN, J.[3], HOOD, J.[1], MANUBOLU, M.[1], RUDSTAM, L.[6], WATKINS, J.[6], LUDSIN, S.[1], [1]The Ohio State University; [2]Miami University; [3]U.S. Environmental Protection Agency; [4]Fisheries and Oceans Canada; [5]Purdue University/Illinois-Indiana Sea Grant; [6]Cornell University. **Effects on harmful algal blooms on foraging habits of western Lake Erie walleye**.

Harmful algal blooms (HABs) have increased in their severity and frequency in Lake Erie during recent decades due to nutrient pollution and climate change. These blooms have a high potential to degrade habitat for aquatic organisms by reducing water clarity, decreasing availability of prey to higher consumers, and increasing toxin levels. The impact of HABs on aquatic food webs, however, remains poorly understood in Lake Erie, as well as most other ecosystems. Towards this end, we sought to understand the degree to which HABs influence the foraging habits of juvenile and adult walleye (Sander vitreus), an abundant, large-bodied predator in Lake Erie that supports valuable commercial and recreational fisheries. Given the potential detrimental effects of HABs on fish habitat quality, we hypothesized that foraging would differ inside versus outside of HABs. Specifically, we predicted that consumption would be lower inside versus outside of blooms with walleye consuming more invertebrates (e.g., zooplankton, benthic macroinvertebrates) inside of blooms than outside of them, owing to known negative effects of reduced water clarity on piscivore foraging. We tested this hypothesis by analyzing the diets of age-0 and older walleye collected inside and outside of blooms in the western basin of Lake Erie during summer 2019. While analyses are ongoing, diet composition differed between locations with age-0 walleye diets being characterized by Leptodora kindtii and Daphnia spp. inside of blooms and Bythotrephes longimanus outside of them. Unexpectedly, walleye piscivory did not appear deterred

inside of blooms. In discussing these and other impending findings, we will seek to offer recommendations to management Lake Erie agencies that want to learn if HABs need to be considered in their management.

HASSAN, Z.[1], JEFFERSON, A.[1], AVELLANEDA, P.[2], BHASKAR, A.[3], [1]Kent State University; [2]Indiana University; [3]Colorado State University. **Assessment of Climate Change Impacts on Cleveland (Ohio) Urban Streamflow**.

Continuous changes in precipitation patterns and rising air temperatures due to climate change are expected to have a significant impact on both high and low flows in streams. Understanding the impacts of climate change on the flow regime of urban streams is particularly important, given the high population densities and critical infrastructure located in urban watersheds. We evaluate the impact of projected 21st century climate change on the flow regime of the 20.6 km2, 30.3% impervious West Creek watershed (Parma, Ohio), using a calibrated PCSWMM model. Precipitation and temperature outputs of four regional climate models (RCMs) project mean annual precipitation increases by up to 14-36% by the mid 21st century (2046-2070). The analysis of different return periods of stream flow is performed across the four different periods and results indicate that there will be an increase of 36-44% for the 1-year flow, 79-86% for the 5-year flow, and 73-98% for the 10-year flow during the mid-century period (2046-2070) as compared to historical period. The results from event-based analysis of precipitation and rainfall indicates that there will be more frequent rainfall in the future with greater intensity that will lead to higher peak flows into the stream. These changes will increase flood risk and decrease performance of existing green and gray infrastructure. Installation of new infrastructure, sized appropriately for future climates, may increase the resilience of urban watersheds to some of the effects of climate change.

HEATLIE, T., NOAA. **Habitat Restoration within Coastal Areas of the St. Clair-Detroit River System (SCDRS)**.

The Great Lakes are one of our country's most important natural resources supporting agriculture, transportation, and recreation services. Coastal marshes provide reproductive, rearing, and protective habitats for diverse populations of fish and other wildlife. However, land use changes have altered coastal wetlands and their processes. This is particularly evident within the St. Clair-Detroit River System (SCDRS), the connecting waterway between Lake Huron and Lake Erie, including Lake St. Clair. These threats have made habitat restoration activities increasingly more important and necessary within this region as a means to improve and preserve our important coastal resources. NOAA's Restoration Center focuses on protecting, maintaining and expanding existing coastal wetland resources through targeted restoration and rehabilitation. Much of the work being done in the region is due to the strong relationships that NOAA's Restoration Center has with non-profit organizations, state and local governments, and academic institutions. This talk will focus on the restoration activities that NOAA and its partners are working on within the SCDRS, but not geographically located in one of the five SCDRS Areas of Concern. Specific projects to be described involve wetland restoration, shoreline softening and other nearshore aquatic habitat restoration within Lake St. Clair and the Western Lake Erie Basin. These projects are specifically helping to address the softening shoreline and coastal wetland restoration priority objectives established for the SCDRS Initiative.

HECK, J., NOAA National Geodetic Survey. **The International Great Lakes Datum: Foundational Infrastructure for Monitoring Lake Levels**.

A fundamental requirement for relating measurements of water levels, depths, volumes and flows throughout the Great Lakes is a common height reference system or vertical datum. The International Great Lakes Datum (IGLD) is such a datum. The Vertical Control-Water Level Subcommittee of the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data, a bi-national committee with representatives from the Governments of the United States and Canada, updates IGLD every 25-35 years to account for the effects of glacial isostatic adjustment (GIA) throughout the region. IGLD (1985) is the current datum, and it will soon be updated to IGLD (2020) to support the infrastructure needs of a changing world with evolving technology. IGLD (2020) will be defined by four attributes: 1. A reference zero that matches the value being adopted for the North American-Pacific Geopotential Datum of 2022 (NAPGD2022), 2. A reference equipotential surface that will be equivalent to that of NAPGD2022, 3. A reference epoch of 2020.0 equal to the central epoch of the 2017 – 2023 data collection period for water level observations, and 4. The use of dynamic heights for water level management. IGLD (2020) will be accessed primarily through Global Navigation Satellite System (GNSS) observations, which is a fundamental change from the leveling techniques that provided access to previous versions of IGLD. The realization of IGLD (2020) will be done through continuous GNSS stations and a large GNSS survey campaign on bench marks at water level stations throughout the Great Lakes and St. Lawrence River system. In addition, water level measurements being carried out at permanent and seasonal gauges will be used to determine the topography for each of the Great Lakes in order to correct for possible hydraulic effects. This presentation will show the latest in these efforts, particularly those around Lake Erie.

HELMER, C., TESSIN, A., GALLAGHER, T., SMART, K., Kent State University. **Investigating eutrophication as a driver of methanogenesis in the western basin of Lake Erie**.

Increased blooms of cyanobacteria have been plaguing Lake Erie in recent decades, having profound negative impacts on the regional environment, including cyanotoxin production and the development of hypoxia (Steffen et al, 2014). One potential impact of algal blooms is that they deliver organic carbon to the lakebed, which can drive the consumption of oxygen and other electron acceptors within sediments, eventually resulting in methanogenesis. Emissions of the greenhouse gas methane from Lake Erie have been studied but have yet to be directly linked to eutrophication and sedimentary production in the Great Lakes (Fernandez et al, 2020). Consequently, the hypothesis of this study is that algal blooms in Lake Erie are contributing to an increase in methane fluxes due to the process of sedimentary methanogenesis. To determine if this hypothesis is true, sediment and pore water data will be analyzed from samples collected during July 2021 from two sites in the western basin of Lake Erie. Total carbon concentration in the sediments will be measured to see if the amount of carbon can be linked to the amount of methane produced. To reconstruct the sediment depths at which different organic matter mineralization pathways dominate, the concentrations of electron acceptors and products will be measured. Pore water dissolved inorganic carbon isotopes and methane concentrations will provide direct evidence for where methanogenesis is occuring. Preliminary findings suggest that methanogenesis is taking place at relatively shallow depths below the lakebed (within 10 centimeters of the sediment water interface). Thus, there is potential for substantial methane release to the water column. The shallow depth of methanogenesis also suggests that oxidants are being rapidly consumed within centimeters of the sediment-water interface The results of this study will be able to indicate if eutrophication of Lake Erie is contributing to methane production. References Cited:Fernandez, Julianne et al., Journal of Great Lakes Research, 2020

Steffen, Morgan et al., Journal of Great Lakes Research, 2014.

HEMKER, W., University of Akron. **Reducing Phosphorus Runoff and Harmful Algal Blooms in Lake Erie Using Vegetated Solutions in Farm Production**.

Biological processes are scalable natural solutions to reduce harmful algal blooms (HABs) in Lake Erie. Phosphorus (P) speciation on seven sites with two Ohio soil types show statistically different than predicted for soluble reactive (SRP), iron/aluminum-P (FeAl-P) residual organic-P (ResP) and total P (TP). Tilled cropland loses organic matter, and P in soils increases. Under saturated soil conditions, iron/aluminum-P (FeAl-P) is unstable (ferric iron converts to ferrous iron) and consequently soluble reactive phosphorus (SRP) is released and drains off into waterways, driving HABs. Reducing saturated soil conditions reduces the loading of SRP into waterways. The roots of herbaceous cover crops and field-edge deep rooted native plants increase soil pore space and tie up phosphorus (P) in an organic form. Increased pore space of the plants improves soil structure, allowing more water to be stored in the soil, thereby reducing runoff flows that carry away phosphorus. Lake Erie's large P runoff occurs in major rainfall events (3-5 inch rains). Plant roots also absorb the SRP, retaining P in plant vegetation or organically sequestering it in the soil; keeping it out of drainage flows entering Lake Erie. The plant roots also keep soil in place, preventing soil erosion. Eroded, P-laden sediment can release SRP, responsible for driving HABs in Lake Erie. Each pound of SRP reaching Lake Erie can potentially produce 500 pounds of harmful algae. Using herbaceous vegetation to keep P in the soil and out of Lake Erie are natural biological tools addressing a watershed ecosystem imbalance. Farm production practices using cover crops and field-edge, ditches, and riparian plantings of native deep root prairie are impactful tools to significantly reduce SRP entering Lake Erie, thereby obviating HABs.

HENDERSON, H., Great Lakes Environmental Research Laboratory. **Sea chest sees it best: pCO2 and water quality monitoring in Lake Erie's western basin using a ship-mounted flowthrough system**.

Spatiotemporal variation in carbon dioxide (CO2) exchange over large freshwater lakes lacks repeated and/or resolute observation. The biogeochemical and atmospheric fluxes mediating this exchange are incredibly variable, even more so in the receiving water bodies of heavily developed and productive waters such as western Lake Erie. Beginning in July 2021, a sea chest based flowthrough system was installed on NOAA's R/V 4108 for each Harmful Algal Bloom Monitoring cruise. Mirroring a pCO2 selective membrane configuration developed at the University of Wisconsin-Milwaukee, the concept was expanded to include a multi-parameter sonde recording chlorophyll-a, blue-green algae, pH, conductivity, dissolved oxygen, fDOM, and turbidity. Programmed mechatronics allow for sample port switching to measure the less variable atmospheric pCO2 concentration every three minutes while underway, thus allowing intake water from below the ship to equilibrate and offgas through the membrane nearly continuously. Additional parameters such as pH allow for larger carbonate series consideration while indicators of productivity (e.g. dissolved oxygen, chlorophyll a) give insight into potential pCO2 mediators.
Is western Lake Erie a source or sink of CO2? That depends on the hour - often varying by hundreds of umol/mol over less than a few kilometers of ship movement as observed in many monitoring cruises this year, with differences between air and water concentrations equally as high in magnitude. Continued monitoring and subsequent advancements in understanding such stochastic fluxes are certain to increase in importance alongside changing atmospheric carbon dioxide concentrations and predicting where large, productive lakes may trend regarding issues as large as global climate change.

HENDERSON, H.[1], MILLER, R.[1], MCKINNEY P.[2], HOLLENHORST, T.[2],[1]Great Lakes Environmental Research Laboratory; [2]U.S. Environmental Protection Agency. **Buoyancy versus benthos: Hypoxia monitoring in Lake Erie's central basin with autonomous underwater gliders**.

The presence of hypoxia (dissolved oxygen <2 mg/L) in the central basin of Lake Erie can exhibit large spatiotemporal variability. Wind-driven transport produces upwellings of hypoxic water, often near public drinking water intakes and in areas of important recreational and commercial fishing activities. The central basin can possess a hypolimnion thickness varying from 5 meters to less than a meter, which can pose challenges to monitoring. Methods of observing this seasonal phenomenon now include autonomous underwater vehicles (AUVs), with four successful deployments from 2019 to 2021. Underwater gliders (Teledyne Webb Slocum) are capable of resolute data collection in spatially variable areas of interest, and are able to do so regardless of sea state. Gliders alter their buoyancy to dive and climb, thus producing many angled water column profiles of respective biogeochemical parameters. Commanded diving behavior generally aims to maximize vehicle endurance and speed of forward progress. However, in shallow water deployments (<50m), parameters such as flight angle must be adjusted to avoid bottom strikes, particularly while sampling within 1-2 m of the lakebed as is necessary for determining the presence of a thin hypolimnion. Furthermore, avoiding bottom strikes is reliant on the AUV's altimeter to command the vehicle to inflect once it reaches a desired distance from the lakebed, with precision proving difficult in the soft substrate of the central basin. Other challenges include progressive fouling of the glider's hull and sensors due to ferro-manganese oxide accumulation. Accumulating experience among glider operators in the Great Lakes and a thorough review of these shallow water operations is sure to further the ability of these vehicles to monitor such dynamic events. The increased effectiveness of these missions is important for researchers and stakeholders alike, whose shared goal is to protect and inform the millions who recreate, cultivate, and consume Lake Erie.

HENDERSON-DEAN, B.[1], SANDHU, L.[2], [1]University of Findlay; [2]Blanchard River Watershed Partnership. **Monitoring Antibiotic Resistant Populations as a Correlative to Water Quality**.

Agricultural land use can have adverse effects on the surrounding waterways which may cause environmental and economical disturbances including but not limited to species assemblage disruption, loss of habitat and wildlife, and human health impacts. There is a need for monitoring in-vivo aquatic systems, specifically those in agricultural areas, to not only provide a more holistic view into correlations between agricultural land use and aquatic environment disruption but also to develop more succinct and effective monitoring and management guidelines. The Blanchard River serves as an excellent model system suitable for monitoring antibacterial resistant microbe sustainability within a highly agricultural area that serves as a contributor of the Lake Erie basin. Several indicators suggest that the Blanchard River watershed may provide a suitable habitat for the antibiotic resistant microbes including MRSA (methicillin resistant S. aureus). Previous studies have provided evidence that antibiotic resistant bacterial reservoir expansion to livestock has a causal link to ca-MRSA (community-acquired) presence in local freshwater sources. One-hundred and twenty-six sites within the Blanchard River and its tributaries were monitored for antibiotic resistant microbes including MRSA. All sites had antibiotic resistant populations while twenty-six of the sites harbored MRSA. There was no correlation between land usage and prevalence of resistant populations including MRSA. Sixteen of the sites were further chosen in conjunction with the Blanchard River Watershed Partnership to determine if traditional water quality measures such as macroinvertebrate populations, nutrient concentrations, and coliform numbers correlate with antibiotic concentrations and resistant populations. Outside nosocomial settings, minimal research has been completed to determine the reservoir of ca-MRSA and other resistant microbes.

HERZOG, M., Cleveland Water Alliance. **Smart Community Science: Credible Water Quality Monitoring for Lake Erie Communities**.

Over time, individual community water issues have prompted the development of a robust, but fragmented, organizational landscape that approaches data collection, management, and use protocols on a watershed-by-watershed basis. Variability in collection and management protocols make direct comparison of data collected by different volunteer groups difficult. As a result, it has been challenging for State, Federal, Academic, and other actors to effectively leverage Lake Erie's existing citizen science infrastructure to address our region's most pressing management needs. What standards for the collection, management, and use are needed to ensure collection of community science data with KNOWN credibility. What current "citizen science" certifications exist through State, Provincial, or Federal frameworks? What alternatives are being developed to encourage closer collaboration with researchers and decision makers? What would it look like for local monitoring programs to collaborate for regional benefit? Now that we have a sense for what community science groups can do for their neighbors, decision makers, and academia, it's time for us to explore the ways that community science groups can work together. A range of organizations and collaborations, including Water Data Collaborative, Cleveland Water.

HILLING, C.[1], BOASE, J.[2], CHIOTTI, J.[2], DEBRUYNE, R.[3], DROUIN, R.[4], MAYER, C.[3], TYSON, J.[5], WILLS, T.[6], ROSEMAN, E.[1], [1]U.S. Geological Survey; [2]U.S. Fish and Wildlife Service; [3]University of Toledo; [4]Ontario Ministry of Northern Development, Mines, Natural Resources, and Forestry; [5]Great Lakes Fishery Commission; [6]Michigan Department of Natural Resources. **How well are we measuring fishery responses to habitat restoration in the St. Clair-Detroit River System?**

The St. Clair-Detroit River System (SCDRS) connects Lake Huron to Lake Erie and is comprised of the St. Clair River, Lake St. Clair, and the Detroit River. The SCDRS is an important navigational and recreational resource and provides important habitats for many Lake Erie fishes. However, portions of the SCDRS are designated as Great Lakes Areas of Concern. Many efforts to address beneficial use impairments have focused on restoring habitat for native fishes and improving the overall health of the aquatic ecosystem. Although a considerable research effort has addressed site-based responses to habitat improvements, many long-term fish surveys are conducted annually in the SCDRS and Lake Erie. However, some questions remain related to whether these habitat enhancements will produce population-level benefits for target species in the SCDRS. Further, do existing monitoring surveys provide the means to assess whether management objectives are being met? To identify monitoring gaps and inform long-term monitoring program development, we compared outputs from SCDRS fish monitoring surveys with performance measures specified in management plans. We inventoried fish monitoring surveys based on discussions with regional management and science agencies and performance measures were collated based on grey literature searches. Fishes subject to fisheries generally had specific performance measures that aligned well with outputs of existing surveys. At-risk fishes often had objectives and performance measures that reflected knowledge gaps and additional study needs. Although fishes subject to fisheries were well-monitored relative to specified performance measures, at-risk fishes were less reliably collected by existing surveys, except for Lake Sturgeon (Acipenser fulvescens). Due to rarity and specific habitat requirements of many at-risk fishes, focused surveys may be necessary to track the effect of habitat restoration on SCDRS at-risk fishes.

HOHMAN, B., Erie Soil and Water Conservation District. **Monitoring to Communication**.

The Firelands Coastal Tributaries Watershed program uses citizen scientist to expand the knowledge of local watersheds to drive management decisions and engage the public. This program is possible through unique partnerships and dedicated volunteers as well a strong collection to communication approach. Each year data is used to develop water quality report cards for the community. These report cards have served to motivate and target needed actions to improve our streams that feed Lake Erie. Our program has been successful because of our commitment to engaging our community in volunteering, education, and opportunities.

HOOD, J.[1], HUDDLESTON, A.[1], COLLIS, L.[1,2], MARSCHALL, E.[1], [1]Ohio State University; [2]NOAA Great Lakes Environmental Research Laboratory. **Western Lake Erie Zooplankton Dynamics Are Shaped by Winter Ice Cover and Summer Cyanobacteria Blooms.**
Declining lake ice cover presents an urgent need to better understand how ice influences lake ecology. During winter, ice cover influences numerous aspects of lake physiochemistry and ecology; however, we know little about whether the effects of ice cover on populations and communities persist through the growing season or if they dissipate as water temperatures warm and factors such as cyanobacteria become potentially important. These dynamics are particularly important to understand for zooplankton, which play an important role in lake food webs as a trophic link between phytoplankton and fish. To better understand whether the influence of winter ice cover persists through the spring and summer, we analyzed patterns in zooplankton community composition and biomass in the western basin of Lake Erie during May–September of 2011-2019. We considered three time periods: May (Spring), June to mid-July (early summer), and mid-July to September (late summer). Spring zooplankton communities were best distinguished by ice cover and temperature, while early summer communities were distinguished by cyanobacteria density, and late summer communities were distinguished by winter ice cover and cyanobacteria density. Ice cover also influenced the biomass dynamics of zooplankton major groups during May–September. Small cladocerans and rotifers exhibited higher biomass in springs following high ice winters while large cladocerans and calanoids exhibited the opposite pattern. After controlling for cyanobacteria density and temperature, ice cover was an important factor in predicting zooplankton biomass during May–September, suggesting that winter conditions help shape the trajectory of seasonal zooplankton dynamics likely through both direct effects on individual species and indirect effects on physiochemical and food web dynamics. Our results contribute to the understanding of how ice cover influences lake ecology and sets expectations for zooplankton dynamics in a future without ice.

HOUSTON, B., In-Situ, Inc. **Low cost, real-time water quality buoys for monitoring expansion in Lake Erie**.

Data buoys are the backbone of the Great Lakes Observing System due to their capability of collecting crucial information about the local lake and atmospheric conditions and transmitting that data in real time via telemetry systems. These platforms provide critical data for stakeholders all around Lake Erie to use for real-time alerting, forecasting models, HAB monitoring, climate change research, along with many other uses. Continuous water quality monitoring is a crucial part of these data streams, as water chemistry and biological activity are powerful indicators of the health and condition of the lake. As technology progresses, sensing and communication instrumentation and platforms have become much more capable while simultaneously becoming smaller and more affordable. Small, low-cost buoys can be advantageous as GLOS expands the network of monitoring stations to allow for more systems to be deployed while reducing costs of maintenance and mobilization. For applications in which a smaller buoy with a reduced payload is sufficient, we

present here a low-cost, single-person deployable buoy for continuous water quality monitoring with real-time data telemetry.

HRYCIK, A., KARATAYEV, A., BURLAKOVA, L., MEHLER, K., SUNY Buffalo. **Assessment of Lake Erie Dreissena populations with video methods**.

Dreissenid mussels are widespread in Lake Erie. Their patchy spatial distributions and distinctly different population dynamics in each lake basin necessitate novel, intensive sampling methods at numerous stations to develop distribution maps and better understand population sizes. We employed three methods of video imaging to gain a better understand of mussel abundance in Lake Erie. First, we employed a drop-down camera at 92 stations to measure Dreissena presence/absence, percent coverage, and density. This method was accomplished in near-real time, as we processed images aboard the R/V Lake Guardian while sampling. Next, we estimated Dreissena abundance with a camera attached to a Ponar grab at 32 stations to expand the area where Dreissena were sampled with the Ponar. Finally, we took video from a benthic sled with a camera mounted on the front at 21 stations. All three video methods were paired with Ponar grab samples for comparison with physical samples of Dreissena and to convert percent coverage to density and biomass. We found that Dreissena density and biomass have declined in all basins. In addition, mussels tend to be smaller and younger in the Western and Central Basins where hypoxia is prevalent and larger and older in the Eastern Basin where recruitment appears to be limited. Video methods corresponded well with traditional Ponar grab sampling and video samples were processed more quickly than grab samples. However, video sampling was least successful in the Western Basin due to high turbidity. Combining novel video methods with traditional Ponar sampling expands the area sampled and greatly improves Dreissena population estimates.

HUNTER, R.[1], SARD, N.[2], DEBRUYME, R.[3], ROSEMAN, E.[3], SCRIBNER, K.[4], [1]University of Toledo; [2]SUNY Oswego; [3]U.S. Geological Survey; [4]Michigan State University. A**ssessing constructed spawning habitat use by adult Lake Sturgeon through sibship reconstruction**.

In the St. Clair-Detroit River System, large-scale, collaborative habitat remediation efforts reestablished portions of lost lithophilic spawning habitat with constructed spawning reefs. To quantify constructed reef use by threatened Lake Sturgeon (Acipenser fulvescens), eggs and dispersing larvae collected before and after reef construction were enumerated. Initial results showed compelling increases in numbers of eggs and dispersing larval Lake Sturgeon following reef construction. Since adult Lake Sturgeon are highly fecund, collected offspring may result from relatively few adults and spawning adult numbers were unknown. Therefore, numbers of adults spawning at constructed reefs in the St. Clair and Detroit Rivers in 2015-16 were estimated from sibling relationships inferred using collected offspring genotypes. Collected offspring (n = 725) were genotyped across 18 loci (13 disomic, 5 polysomic) with n = 205 possible alleles and sibling relationships were reconstructed using COLONY where individuals were assigned to full- and half-sibling groups. Results suggested 330 unique adults contributed offspring in 2015 and 2016. Further, inferred sibling relationships between larvae reared from collected eggs provided evidence that adults contributed offspring at multiple locations within years. Simulations demonstrated sufficient power for inference, but further analysis suggests that different levels of coancestry between sampling methods may affect estimated adult numbers, and sibship reconstruction only provides information about the number of adults contributing offspring to a sample. We then demonstrated that pedigree rarefaction methods applied to inferred genetic families can extrapolate the total number of spawners contributing offspring at a site. Results demonstrate potential benefits of constructed spawning habitat for lithophilic spawners like Lake Sturgeon, and provide insight into implications of collection methods on interpretation of pedigree reconstruction methods. Methods

further demonstrate a technique for estimating total numbers of spawning adults from reconstructed offspring pedigrees by combining traditional statistical methods from community ecology and population genetics to inform management.

I

INSLEY, S., North Olmsted City Schools. **Lake Erie-Great Lake, Great Opportunity**.

Real world science lessons I learned onboard the R/V Lake Guardian to bring into my science classroom. Use Lake Erie as a learning tool in your classroom! Show students what real-world science is and get outside to collect and work with water quality data using the Hydrolab with the Limno Loan Program. The multifaceted Limno Loan Program, coordinated by Illinois-Indiana Sea Grant with the Center for Great Lakes Literacy and USEPA, trains and loans the Hydrolab, a data sonde, to educators. Students are able to collect and analyze water quality data from the field with actual equipment used by scientists. Hear about accounts from students in the field and see how to use the Hydrolab first hand in your classroom. Get your students outside and grow the next generation of Great Lakes aquatic scientists!

ISLAM, R., Ohio State University. **Performance of bio-based dipolar adsorbent to control edge-of-field phosphorus loss**.

While phosphorus (P) is one of the essential nutrients important for crop productivity, it often associated with environmental problems especially harmful algal blooms, cyanotoxins, and water quality degradation. A field study was conducted at The Ohio State University South Centers to evaluate the performance of plant-based dipolar adsorbent for its ability to bind and retain soluble reactive phosphorus (SRP) from agricultural runoff and drainage under variably-tilled continuous corn system. The runoff and drainage passed thru the control and adsorbent were collected after major rain events and snowmelts, processed and analyzed for SRP, chemical oxygen demand (COD), biochemical oxygen demand (BOD), total sediments, reactive N, pH, and electrical conductivity (ECw), respectively. The adsorbent was analyzed for its nutrients content and field decomposition properties to be recycled as a P fertilizer. Results showed that the adsorbent significantly reduced the SRP concentration in both drainage and runoff when compared with the control. Averaged across time, the SRP concentration in drainage was reduced by 73% under plowing (CT) and 87% under the no-till (NT) when compared to the control. Likewise, runoff SRP concentration decreased by 33% under the NT and 70% under the CT. When compared with the control, the total sediment loss (trapped by the adsorbent) was 15% under the NT and 60% under the CT. The adsorbent had similar non-linear field decomposition characteristics under both tillage systems; however, the decomposition was slightly faster under the CT when compared with the NT. The regression modeling suggested that the adsorbent will decompose completely within a year after its application and the half-live is only 45 days.

J

JABOT, M., SUNY Fredonia. **Development of a citizen science monitoring program for Lake Erie Tributaries**.

This presentation will share the implementation of a citizen/community driven stream monitoring program on the Lake Erie tributaries in Southwestern NY. The overall design will be shared as will strategies for replicating this work at participants locations.

JACQUEMIN, S., ZEHRINGER, M., KLINE, K., Wright State University, Lake Campus.
NUTRIENT REMOVAL POTENTIAL OF RESTORED WETLANDS: LESSONS FROM GRAND LAKE ST MARYS WATERSHED FOR H2OHIO.

The vast majority of wetlands across the Midwest have been lost as a result of agricultural land development dating back to colonial settlement. However, recent water quality conservation initiatives (such as H2Ohio, 319, CRP, EQUIP, or WRP) have begun to slowly reverse this trend, as these systems have become increasingly prioritized for their role in mitigation of nonpoint source runoff. Consequently, there is a need for basic information related to nutrient reduction potential, including source-sink dynamics, as well as optimal design frameworks (residence time, configuration, and relative watershed footprint). Therefore, the objective of this study was to use the long-term Coldwater Creek Wetland (Grand Lake St Marys Watershed) dataset to parse out these parameters. This dataset is unique as it contains 5 years of complete weekly records of nutrient and sediment concentrations and hydrology as well as engineering design schematics. Moreover, it is situated on a creek with high concentrations (mean mg/L) of nitrate (5.3), dissolved phosphorus (0.13), total phosphorus (0.38), and suspended solids (46.8) that vary throughout the year. Additionally, flow into the wetland is actively controlled via a pump, providing an opportunity to assess how important active management is to wetlands. Nutrient and TSS reduction efficiencies are contingent on residence time and season (e.g. plant and microbial activity) as the wetland can range from source to sink. To maximize time as a sink (with reduction efficiencies up to 95+%), active management of the system includes adjusting pumping rates for residence times of 2 to 5 days during spring, summer (most efficient), and fall. This 30-acre wetland (0.3% subwatershed area) processes ~10% of annual streamflow and sequesters 1.5%, 4.5%, 3.5%, and 5% of total annual load of NOx, TP, SRP, and TSS, respectively, making this kind of wetland design and management a prime candidate for expansion across the Midwest.

JEFFERSON, A.[1], GREISING, C.[1], FAROOQ, N.[1], STACHEW, E.[2], BROWN, E.[3], KEARNS, K.[1], MURATORI, S.[1], SCHROECK, J.[1], SNYDER, K.[1], YUPA, G.[1], MITCHELL, A.[1], CHAKRABORTY, A.[4], [1]Kent State University; [2]University of Akron; [3]Cleveland State University; [4]Case Western Reserve University. **Plastic dynamics in Cleveland streams and beaches, with implications for Lake Erie**.

The degradation of macro-plastic items is likely to be a significant source of micro- and nano-plastics in Lake Erie and other water bodies. Urban streams and shorelines are potential sources and routes of plastic pollution reaching the lake. In this study, we investigated the dynamics of macro- (>5 cm) and meso- (> 2 mm) plastic debris in 14 Cleveland area stream reaches and 1 beach during summer 2021. Plastics accounted for about 73% of debris within stream channels and about 81% of macro-litter on the beach, though the proportion of plastic items to all debris varied by location and sampling date. In samples of the top 5 cm of beach sand, small fragments of brick outnumbered plastic pieces, and the majority of plastics were foams or pre-production pellets. At the beach, spatial variability in litter abundance appears to be a function of grooming and possibly intensity of visitor use. Areas with higher abundance of macro-litter also had more meso-litter on the sand surface. Of eight sampling dates, the Tuesday following Memorial Day had the most litter. Two stream reaches were also sampled repeatedly, and across dates, the stream reach downstream of a commercial area generally had more litter than the reach downstream of a park. The abundance and variable distribution of macro- and meso-plastics suggest that targeted stream and shoreline capture and cleanup efforts may be able to reduce the generation of microplastics in Lake Erie.

JOOSSE, P., MCPHEE, C., Agriculture and Agri-Food Canada. **Canada's Nationwide Network of Agroecosystem Living Labs**.

Agriculture and Agri-Food Canada's Living Laboratories Initiative uses a new approach to agricultural innovation in Canada that brings together farmers, scientists, and other collaborators to co-develop and test innovative practices and technologies to address agri-environmental issues. The goal is to accelerate the development and adoption of sustainable practices and technologies by Canadian farmers. Forming a nation-wide network of agroecosystem living labs, the initiative focuses on innovative solutions to environmental issues related to agriculture, such as climate change, soil health, water quality and biodiversity. The concept of agroecosystem living labs is relatively new in the innovation and research world; Canada is advancing the concept with various international collaborators, including France's National Research Institute for Agriculture, Food and Environment (INRAE), the European Network of Living Labs (ENoLL) and the USDA Long Term Agroecosystem Research Network. Core principles of living labs include user-centred innovation, working in partnership, and testing in the user's real-life context. This presentation will highlight what agroecosystem living labs are and how they are being implemented across Canada, including through the AAFC's new 10-year Agricultural Climate Solutions program, which will result in at least one living lab in every province.

JUBAR, A., U.S. Fish and Wildlife Service. **Sea Lamprey Assessment in the St. Clair- Detroit River System 2011-2021**.

The U.S. Fish and Wildlife Service (FWS) and Fisheries and Oceans, Canada, (DFO) work as agents of the Great Lakes Fishery Commission (GLFC) to deliver integrated control of invasive sea lamprey throughout the Great Lakes. Adult sea lamprey abundance in Lake Erie decreased slightly in 2021, and remains below target and holding steady. It should be noted, however, that due to the pandemic only two adult index streams could be surveyed using mark-recapture in Lake Erie in 2020 and 2021. Additionally, no lampricide treatments of infested Lake Erie streams occurred during 2021. The St. Clair-Detroit River system (SCDRS) is known to harbor a larval sea lamprey population within the confines of the St. Clair River (SCR) as well as in the delta of Lake St. Clair. Historical assessment of this population suggested that density was low, infestation widespread, sea lamprey production likely minimal, and that sea lamprey mortality during migration through the SCDRS would result in a minimal contribution of parasitic sea lamprey to the Lake Erie basin. Because assessment information from other tributaries to Lake Erie could not identify an untreated source of sea lamprey production, the control agents intensified assessment effort on the SCDRS during 2011-2014. Following extensive larval survey effort in 2014, the larval sea lamprey population of the St. Clair River was estimated to be 919,509. From 2015-2021, a baseline effort of larval surveys was applied along with alternative sampling for outmigrating juvenile sea lamprey. Survey findings continue to indicate a significant larval sea lamprey population persists throughout the SCR. Although potential sea lamprey control scenarios in the SCR have been solicited by sea lamprey program managers, there are currently no plans to implement large scale treatment effort within the river. To date, no larval sea lamprey have been collected in the Detroit River, although native lamprey species are present.

K

KANE, D.[1], MANNING, N.F.[1], JOHNSON, L.T.[1], RAZZANO, M.[2], [1]Heidelberg University; [2]Ohio Environmental Protection Agency. **CLEVELAND ROCKS(alt): Increases in Cuyahoga River Chloride Concentrations during the last 4 Decades**.

Previous studies of river ecosystems in the Midwest and Northeast have shown that increasing chloride concentrations are due to increased road salt application and are correlated with the amount of urbanization in a watershed. Using 35+ years of data from the Heidelberg Tributary Loading Program for Lake Erie tributaries we found that mean concentrations (mg/L) of chloride increased significantly and substantially over time in the Cuyahoga River (most urbanized watershed) but not in the Sandusky and Maumee rivers (agricultural watersheds). Further, we apportioned the data seasonally to determine if river chloride levels were greater during seasons of road salt application (Winter) and snowmelt (Spring). Seasonally, winter levels of chloride exceeded the USEPA chronic water quality criteria concentration of 230 mg/L in more than half of the years of the 21st century, compared to only 1 year exceeding this value in the late 20th century. Additional Ohio EPA data have allowed us to investigate which Cuyahoga River tributaries have high chloride values, information which would be useful for future remediation efforts. Our findings point both to the importance of continuous, long-term monitoring and the presence of diffuse, nonpoint source pollution impacting the Cuyahoga River. Finally, we discuss our results within the recently developed paradigm of the "Freshwater Salinization Syndrome."

KARATAYEV, A.[1], BURLAKOVA, L.[1], HRYCIK, A.[1], DANIEL, S.[1], MEHLER, K.[1], HINCHEY, E.[2], DERMOTT, R.[3], KENNEDY, G.[4], GRIFFITHS, R.[5], [1]SUNY Buffalo; [2]U.S. Environmental Protection Agency; [3]Fisheries and Oceans Canada; [4]U.S. Geological Survey; [5]Aquatic Ecostudies Limited. **Long-term dynamics of Lake Erie benthos: One lake, three distinct communities**.

Nine decades of intensive monitoring of the Lake Erie benthic community provides insights into the nature and impact of anthropogenic-driven changes, including cultural eutrophication, phosphorus abatement initiatives, and the introduction of invasive species, over time. We used multivariate community analyses to examine changes in benthic community composition and drivers of these changes over the last 90 years. The three Lake Erie basins differ significantly in community structure, density, and biomass of benthic macroinvertebrates, as well as in major environmental factors that shape these communities. Eutrophication and Dreissena spp. introduction were the major drivers of changes in benthos in the western basin, hypoxia in the central basin, and dreissenid introduction in the eastern basin. Non-dreissenid community composition of the western basin has dramatically changed over the last 90 years from a healthy, highly diverse community, indicative of good water quality and dominated by Hexagenia in the 1930s, to a community of low diversity dominated by pollution-tolerant species in the1960s and recovered by early 2000s to a state comparable to that of the early 20th century. In contrast, the non-dreissenid benthic community of the central basin over the last 60 years was consistently dominated by low oxygen-tolerant taxa, signifying the persistence of hypoxia, the major community driver in this region of the lake. The eastern basin community has changed dramatically over the same period following the disappearance of Diporeia after the introduction of Dreissena in the 1990s, and more recent declines in oligochaetes, amphipods, gastropods, sphaeriids, and leeches. Although Dreissena spp. became an important component of benthos in all Lake Erie basins, their role as drivers of community structure and function and ecosystem health is most pronounced in the eastern basin and least significant in the western basin, owing to differences in habitat suitability for maintenance of stable dreissenid populations.

KENNEDY, G.[1], KINZEL, P.[2], FISCHER, J.[3], WILLS, T.[4], BOWSER, D.[1], DEBRUYNE, R.[1], ROSEMAN, E.[1], [1]US Geological Survey; [2]Colorado Water Science Center; [3]U.S. Fish and Wildlife Service; [4]Michigan Department of Natural Resources. **Quantifying Physical Maturation of Artificial Spawning Reefs in the St. Clair-Detroit River System**.

Artificial reefs have been constructed to restore spawning substrates for lithophilic spawning fishes (e.g., Lake Sturgeon, Acipenser fulvescens; Lake Whitefish, Coregonus clupeaformis; and Walleye, Sander vitreus) in the St. Clair-Detroit River System since research has shown that recruitment is limited by available spawning habitat throughout this waterway. Early projects used metrics such as proximity to historic spawning locations and appropriate water velocities to guide reef placement. Although eggs of the target species were collected over the artificial spawning reefs, long-term success at some of the artificial reefs was compromised by fine sediments which filled the interstitial spaces needed by developing eggs. In order to improve the longevity of the reefs, geomorphological criteria were incorporated into site assessments of reefs constructed after 2013 to identify sediment sources and depositional zones. To evaluate the effectiveness of the revised placement process, we quantified physical maturation of artificial reefs using multi-beam sonar and underwater video surveys. Sonar allowed large areas to be quickly surveyed to identify the presence of bedforms upstream and around the artificial reefs, followed by underwater video to examine and quantify the degree of fine-scale infilling within the reefs. To evaluate changes in the reef structure, multi-beam / video surveys were conducted in 2018 and again in 2021. Initial assessments indicated that most reefs constructed using geomorphological placement criteria have experienced limited accumulation of fine sediments. Reefs that did experience early accumulation of sediments also exhibit temporal changes in bedform pattern. These observations indicate that the riverbed is active and mobile and that sedimentation is dynamic. For the majority of the artificial reefs, reef materials remain exposed and available to spawning fishes following construction. Therefore, incorporation of geomorphological placement criteria has improved the longevity of reef restoration projects in the St. Clair-Detroit River System.

KENY, Gebhard., Rice University. **An Anthropological View of HAB Mitigation in Lake Erie**.

Drawing from archival materials, interviews, and participant observation conducted with H2Ohio practitioners, cultural resource managers, and environmental activists over a 15 month period, this presentation aims to contextualize H2Ohio's current interventions into the problem of Lake Erie HABs, specifically its wetland monitoring program, within a broader history of land use practices and future anthropogenic uncertainties throughout northwest Ohio. More specifically, this talk considers how H2Ohio practitioners account for complex mixtures of natural and anthropogenic processes, such as legacy phosphorus release, drainage tile breakdown, wetland management, and climate change, in their monitoring efforts and how such accounting efforts manufacture both a conceptual and physical ground for addressing the problem of HABs in Lake Erie. Central to this discussion is the question of how efforts to create physical and conceptual "levers" within wetlands and across watersheds for the purposes of nutrient removal mobilize a very specific understanding of accountability and responsibility within the problem space of Lake Erie HABs. After detailing how such physical and conceptual levers are produced by a dedicated and diverse consortium of H2Ohio experts, alternative grounds are offered for imagining HAB accountability and responsibility. The presentation then closes by considering the extent to which such alternative frameworks are commensurate with H2Ohio's conceptual, economic, and legal orientation to HABs and what it would take to bridge such gaps should we wish to do so.

KERETZ, S.[1], WOOLNOUGH, DAELYN A.[1], MORRIS, T.[2], ZANATTA, D.[1], [1]Central Michigan University; [2]Fisheries and Oceans Canada. **Species distribution modeling for native and invasive mussels in the St. Clair and Detroit rivers**.

Native freshwater mussels (Bivalvia: Unionidae) were seemingly pushed to extirpation following the introduction and establishment of dreissenid mussels within the St. Clair–Detroit River system of the Laurentian Great Lakes region. Unionids have been considered extirpated from the Detroit River since 1998 and, although unionid populations have been found in the St. Clair delta, the state of unionids in the main channel of the St. Clair River remains unknown. To assess the potential remnant unionid populations, the Detroit and St. Clair rivers were surveyed in 2019 and 2021, respectively, using a mixture of stratified random, historical, potential refuge, and model-selected sites (n = 56 Detroit River sites and 51 St. Clair River sites). Data collected from the Detroit River in 2019 and MaxEnt were used to create unionid species distribution models which produced the model-selected sites for sampling in the St. Clair River. A total of 220 live unionids representing 11 species were found among 5 sites in the Detroit River and a total of 14 live unionids representing 9 species were found among 7 sites in the St. Clair River. Live unionids found in the St. Clair River were found at all site types except the model-selected sites (n = 6), with randomly selected sites representing 4 of the 7 sites where unionids were present. The model developed from the Detroit River dataset failed to be predictive for unionid presence in the St. Clair River. Updated species distribution models using data from both rivers will contribute towards additional surveys occurring in both rivers in summer 2022. Additional analyses, including the assessment of dreissenid presence in the St. Clair River, are currently underway in an attempt to further our understanding of native mussel distributions in large river systems which will contribute towards unionid conservation and management in the future.

KINSMAN-COSTELLO, L., Kent State University. **The H2Ohio Initiative Wetlands Monitoring Program: Assessing Nutrient Removal in Diverse Wetland Projects**.

Globally, considerable investments are made to protect, restore, construct, and manage wetland ecosystems to improve water quality and mitigate excess nutrient loads that fuel eutrophication. In Ohio, wetland restoration is one of a set of Best Management Practices being implemented statewide as part of Governor Mike DeWine's H2Ohio Initiative to improve water quality throughout the state, with particular interest in diminishing harmful algal blooms in the western basin of Lake Erie. The ODNR-implemented H2Ohio Wetland Projects are diverse and numerous, representing over 50 planned projects including reconnection of diked coastal wetlands as well as wetland restoration and construction on agricultural land and floodplains. The H2Ohio Wetland Monitoring Program (HWMP) includes a multi-disciplinary, coordinated team of researchers developing a long-term data collection framework to assess the nutrient removal effectiveness of H2Ohio Initiative wetland restoration. Measurements will include hydrologic features and dynamics, groundwater exchange, bathymetric and elevation surveys, vegetation, soil characteristics and nutrient status, surface water nutrient concentrations, soil geophysical characteristics, and sediment-surface water nutrient exchange. The HWMP will not only generate valuable knowledge of wetland function, but will also enhance wetland research and management capacity through cultivating a network of wetland researchers and practitioners. Ultimately, the HWMP provide an unprecedented opportunity to compare diverse wetland restoration, construction, and management approaches in terms of direct assessments of both nitrogen and phosphorus cycling mechanisms.

KITCHENS, C., GODWIN, C., Cooperative Institute for Great Lakes Research. **Nearshore to Offshore Distribution 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 discolored drinking water and is increasingly regulated due to human health concerns. 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 conducted a series of targeted transects and repeated sampling stations in the central basin to assess variation in the concentration and forms of Mn from nearshore to offshore regions. Discrete water samples were collected from both the surface and bottom of the water column and paired with measurements of dissolved oxygen and temperature. Dissolved Mn was low but detectable in surface water. Elevated dissolved and total Mn occurred first in nearshore hypoxic hypolimnion, where the 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 anticipate when and where Mn accumulates to concentrations that have potential to impact drinking water treatment.

KOSEK-SILLS, S., Ohio Lake Erie Commission. **Agricultural BMP Implementation Through H2Ohio Programs**.

In 2019, Ohio Governor Mike DeWine unveiled H2Ohio, a comprehensive, data-driven water quality plan to improve the condition of Ohio's water resources. H2Ohio is an investment in targeted solutions to help reduce phosphorus runoff and prevent algal blooms through increased implementation of agricultural best practices and the creation of wetlands; improve wastewater infrastructure; replace failing home septic systems; and prevent lead contamination in high-risk daycare centers and schools. The Ohio General Assembly has invested $342 million in the plan with approximately half of the total dedicated to nutrient reduction to Lake Erie. With two years of implementation complete and two more in progress, we will present the status and future outlook for agricultural practice implementation as part of H2Ohio and describe how it fits into the state's actions to address nutrient reductions as called for in Annex 4 of the Great Lakes Water Quality Agreement.

KOSEK-SILLS, S., Ohio Lake Erie Commission. **Ohio's State of the Lake – Lake Erie Quality Index**.

Ohio's State of the Lake Report: Lake Erie Quality Index outlines conditions in Lake Erie and its watershed that are under the State of Ohio's jurisdiction. Understanding existing conditions and trends in the local environment and economy helps state agencies with protection and restoration of this significant resource. The Index is organized into 6 indicators with 34 individual metrics. The metrics and indicators utilize existing historical databases and ongoing monitoring programs ranging from environmental measures like key species populations to economic information such as shipping tonnage at Ohio ports. Much of the data presented is generated by state agencies for support and evaluation of their existing programs and the Index provides an opportunity to take a holistic look. The 2020 update of the Lake Erie Quality Index shows that many of Ohio's efforts to protect and restore the lake are working, although we have a lot left to learn, and much work still to be done.

KOSEK-SILLS, S., Ohio Lake Erie Commission. **Policy Perspectives and Management Challenges in Addressing Hypoxia in the Central Basin of Lake Erie**.

A large hypoxic upwelling event on September 2, 2021 caused significant public consternation in the Cleveland, Ohio area. Natural gas/sewer odors and a noticeable number of dead fish resulted in more than 60 calls for service made to fire and police departments along the shore. Taste, odor, and appearance problems occurred in tap water. Days later, the public was reassured that the problem was naturally occurring due to upwelling of low oxygen water and not toxic. Despite how well known this phenomenon is to the scientific community, and the existence of a predictive model which correctly provided advance warning to the Cleveland water treatment operators, the hypoxic zone in the lake is not visible or measurable in the same way as are the algae blooms in the Western Basin, and so is not as well known to the public. Hypoxic or anoxic waters at the bottom of Lake Erie's Central Basin are considered naturally occurring, but their extent and duration are understood to be related to excess nutrient inputs to the lake. Therefore, a target phosphorus load of 6,000 metric tons per year was established under the U.S.-Canada Great Lakes Water Quality Agreement to reduce hypoxia. However, the complex and multidimensional nature of hypoxia makes it a difficult ecosystem response indicator for which to assess and gauge progress. We discuss these challenges related to the management and communication to the public of this dynamic feature of Lake Erie.

KOWALSKI, M., Put-in-Bay High School. **Shipboard Science on the R/V Lake Guardian**.

The Shipboard Science Workshop aboard the EPA's R/V Lake Guardian is a one-of-a-kind opportunity to gain an intimate understanding of the Great Lakes. The experience is open to both formal and informal educators alike and is rooted in the Great Lakes Literacy Principles. Participants have the opportunity to work alongside of research scientists in collecting authentic water quality data and having meaningful conversations with other educators about how to utilize that data in a variety of educational settings. Join an alumni "Guardianite" to hear more information about the program and learn about some exciting activities that can be used to engage students in learning about issues affecting our Great Lakes.

KOZORA, C., OTT Hydromet. **Field Monitoring for Nutrients via Remote Deployment with Telemetry**.

Nutrients, both nitrate and phosphorus, have received increasing attention from academics and government agencies due to their potential impact on the formation of Harmful Algae Blooms (HAB). State of the art technologies have allowed environmental managers to detect and continuously monitor nutrients using a variety of methods. One method is the use of deployed stations with nitrate and phosphate sensors coupled with datalogger, telemetry, and data management tools. Quantitative data can be auto-collected and transmitted direct to end-users at custom frequencies and durations. Attendees to this presentation will learn: impact of nutrients on HAB formation; sensors for nitrate and phosphate field monitoring; components of a deployed station; programing options for data collection and transmission; data management for private and public distribution.

KRATT, K.[1], SAKAS, A.[2], BRENNAN, A.[2], MACKEY, S.[3], Thompson, G.[4], Denbow, T.[5], [1]Tetratech; [2]The Nature Conservancy; [3]Ohio Department of Natural Resources; [4]Baird; [5]Biohabitats. **Coastal Water Quality Modeling in Support of the Sandusky Bay Initiative**.

Sandusky Bay is a shallow, freshwater embayment in northern Ohio along the coast of Lake Erie that is impacted by harmful algal blooms (HABs). The HABs result from and are affected by a complicated set of factors that include excessive nutrient loading from the watershed, wave-induced

re-suspension of sediment, fluctuating water levels, and internal loading of nutrients from the bottom of the bay. To improve water quality in Sandusky Bay, the Ohio Department of Natural Resources (ODNR) Office of Coastal Management is leading the Sandusky Bay Initiative, the purpose of which is to construct a portfolio of projects to improve water quality by reducing nutrient loads, increasing water clarity, and restoring waterfowl and fishery habitat. ODNR provided a grant to The Nature Conservancy which in turn hired a team led by Baird and including Biohabitats and Tetra Tech to design a suite of the most promising projects. Tetra Tech's primarily role in the project was to use an Environmental Fluid Dynamics Code (EFDC) model of the bay to simulate the water quality impacts of the proposed projects.

Key processes simulated by the EFDC Sandusky Bay model include: hydrodynamic circulation patterns governed by river flows, winds, lake levels, seiche effects, and bay bathymetry; internal loading of phosphorus and nitrogen resulting from wave action and sediment release during anoxic conditions; complex interactions of nutrient concentrations, temperature, light availability, and other variables on growth of submerged aquatic vegetation (SAV) and phytoplankton. The model runs on an hourly time step and was calibrated for the period 2015 to 2019 and then used to simulate the impacts of the proposed island, nearshore, and living shoreline projects. Key metrics evaluated by the model include how the proposed projects will affect nutrient loading to Lake Erie, the degree to which they will promote the growth of SAV, the number of "good" algal days, and how fish larvae are distributed as they enter the bay from the Sandusky River. The model was also used to assess how conditions in the bay, both with and without the proposed projects, might change under periods of lower water levels. This presentation will summarize the role of modeling in the overall design process and present some of the key lessons learned.

KUZMICK, E., Ohio Department of Natural Resources. **Using Citizen Science to Sustain a Long-Term Phenological Monitoring Program**.

Although climate models examining sea level rise and other oceanic susceptibilities have garnered much attention considering climate change, many are left weighing what climatic changes might mean for the Great Lakes. While there are initiatives that assess the impacts of climate change on water quality (e.g., the System-Wide Monitoring Program (SWMP) records and draws correlations between water quality and weather data) and coastal habitat (e.g., shoreline softening techniques, native vegetation restoration), climatic impacts upon wildlife species are less understood. Phenology-based species monitoring helps develop an understanding of how climate trends impact species that are indicators of or keystone to ecological success within this Lake Erie estuary, ultimately to inform Great Lakes coastal wetland management practices regarding wildlife. The Old Woman Creek National Estuarine Research Reserve's Phenological Species Monitoring Program seeks to monitor wildlife species that either play a key role (e.g., bald eagles) or are indicative to other environmental conditions (e.g., amphibian species) in a model Great Lakes ecosystem. The program monitors species presence and activity relative to climate data, invasive and native species composition, resource availability, and temporal/spatial factors. Protocols are adapted from regional and national initiatives to increase relevancy across scales. The Ohio Coastal Training Program intentionally designed the Reserve's Phenological Species Monitoring Program to be driven via citizen science, both to manage consistent monitoring and provide training, technical assistance, and additional informational resources on wildlife species monitoring, identification, habitat, and conservation efforts. This allows for both outreach and research to be conducted simultaneously. Volunteer engagement and recognition are important aspects to the program's citizen science retention. In navigating a post-pandemic world, it is important to investigate enhanced efficacy to recruit & engage volunteers. Short-term, preliminary species monitoring data for 9 different monitoring initiatives show loose correlation between certain species trends and climate conditions

(e.g., inverse relation of bald eagle incubation time to temperature, muskrat activity in direct proportion to aquatic vegetation cover, prime soil temperature & lungless salamander presence/activity). Long-term analysis/modeling are the next steps for program management.

L

LANG, K.[1], MAYER, C.[1], HINTZ, W.[1], QIAN, S.[1], YOUNG, R.[2], WEIMER, E.[3], NATHAN, L.[4], [1]University of Toledo; [2]U.S. Fish and Wildlife Service; [3]Ohio Department of Natural Resources; [4]Michigan Department of Natural Resources. **Quantifying changes in Lake Erie grass carp mortality rates to assess management success**.

Conditions in Lake Erie favor grass carp (Ctenopharyngodon idella) population growth. This large, invasive herbivore may harm Lake Erie's ecology and economy. The number of grass carp captured in the Lake Erie basin increased by over 1000% from 2012 to 2021, likely due to increased effort and awareness by natural resource agencies. The Lake Erie Committee's Adaptive Response Strategy aims to improve the understanding of grass carp population dynamics and to remove 390 grass carp annually to suppress population growth. Effort has increased every year since 2017, and dedicated crews have captured over 500 grass carp from the basin. However, removal has fallen remarkably short of the LEC's harvest goal every year since its enactment. A biological indicator, such as mortality, can assess changes in the population and may provide a more sensitive way to determine whether control efforts are successful. We modeled mortality rates from before and after the implementation of control efforts in two ways. We developed catch-curves from the ages of captured grass carp to estimate annual mortality for 2014-2021. We then estimated mean annual mortality with a multilevel linear model using the entire time series of age data, a conservative approach that reduces year-to-year variation. Mortality appears to be increasing in both types of analyses. There are positive correlations between mortality and the number of fish harvested per year and the amount of targeted effort, indicating that control is reducing the population. This research directly addresses fishery managers needs to better understand grass carp population dynamics and supports the adaptive management framework that governs the Lake Erie Grass Carp Adaptive Response Strategy.

LAWRENCE, P.[1], DENNISON, B.[2], FRIES, A.[2], BIHN, S.[3], [1]University of Toledo; [2]University of Maryland; [3]Lake Erie Waterkeeper, **Development of an EcoHealth Report Card for Western Basin of Lake Erie**.

The Western Lake Erie Report Card provides a transparent and geographically detailed assessment of the health of the Western Lake Erie basin and watershed in 2018, translated into "A" through "F" letter grades like a school report card. This is the first report card on the ecological health of Western Lake Erie and its watershed. The report card was co-developed with stakeholders from around the Western Lake Erie watershed. Stakeholders identified water quality, toxics, algal blooms, and biology as important to consider to assess lake and watershed condition. The overall Western Lake Erie Basin was in moderate health (C+) in 2018. Category scores ranged from poor (water quality, 28%) to good (algal blooms, 78%). The fish category had a good score (66%). Water quality indicators were poor or very poor except for total nitrogen, which was good. These scores reflect nutrient loading in the basin. Three indicators contribute to the algal blooms category: the bloom index, source water toxin, and recreational toxin. The bloom index had a moderate score (78%) and those three indicators reflect that condition for 2018. Source water toxin and recreational toxin indicators evaluate microcystin levels; both had very good scores in 2018. Report cards are powerful tools used around the world to describe ecosystem status, increase public awareness, and

inform decision makers. This is the first Western Lake Erie Report Card, and it reflects the effort of dozens of stakeholders in the watershed. Through the report card, an information-dense, complex ecosystem health status can be communicated simply and effectively to decision makers and the public. (www.lakeeriereportcard.org)

LAWSON, R., Huron River Watershed Council. **Turning Citizen Science into Action**.

Under the Clean Water Act, federal and state agencies are tasked with ensuring that our waters are safe to drink, fish from and recreate in, but they are provided with woefully inadequate resources to carry out this broad mandate. Universities and local agencies can fill some gaps, but those organizations generally have short-term or more narrow interests and missions. Citizen science can provide needed information to fill gaps or provide screening that these other organizations cannot provide. The Huron River Watershed Council (HRWC) began the Chemistry and Flow Monitoring Program in 2002 in response to community interest in increasing the data available on nutrient contributions to the Huron River and its lakes and tributaries. It was started with 10 volunteers who collected samples for a handful of parameters at nine sites monthly, and it has expanded into the current watershed-wide program with over 100 sites sampled by hundreds of volunteers over the years. The data are intended to lead to a better understanding of pollution from non-point and stormwater sources in subdrainages of the watershed. An improved understanding of sources helps our community partners in the watershed management groups focus and track pollution reduction efforts as they strive to meet pollution limits for different sections of the watershed. HRWC now has one of the richest longitudinal datasets on river and stream chemistry in the region. It integrates this monitoring data into watershed management plans and works with county-based local government management groups to implement projects and programs designed to address problems identified by monitoring data and the success of those programs is evaluated by the same data collection. HRWC also works with its state agency to inform it about issues that are beyond the scope of local efforts. HRWC's program leadership is now working with other citizen science programs in the Lake Erie region to standardize and coordinate efforts to gain a deeper understanding of rivers and streams in the region and inform policy and management at this regional scale. This presentation will provide a thumbnail sketch of how a small group of dedicated and trained citizen scientists can have a big impact on water issues by connecting the science of water monitoring to local and state level policy and management.

LEE, C., WOLLEY, K., AquaRealTime. **Low cost, networked sensor buoys for a scalable algae monitoring program**.

When monitoring waterways, the large areas in question make it difficult to obtain data of sufficient spatial and temporal resolution. Manual sampling, though able to generate high quality data, quickly becomes too expensive and time consuming especially when changes happen quickly, such as is the case with algae blooms. The pricing and installation challenges with sonde based monitoring limit their widespread adoption as they also rapidly scale to prohibitive time and financial commitments. To expand the scientific understanding of water patterns in the great lakes, there is currently a need for continuous monitoring systems that are truly scalable to the tasks of understanding large bodies of water. They need to be accurate, with frequent data streaming to a fully developed dashboard, have low maintenance and cost commitments, and portable enough to be installed, moved, and removed rapidly. The authors propose a novel monitoring system for algae blooms and related parameters that is intended to address this need. In this presentation, the authors will describe how the devices work, the accuracy of the sensing, how the data is transmitted and viewed, how the devices are deployed and maintained, some potential challenges in their usage and

how these are addressed. Case studies of the devices in several representative scenarios will be presented. The authors of this abstract have a financial interest in the product described.

LEHNEN, J., New York Sate Department of Environmental Conservation. **Accelerated Progress in New York's Areas of Concern**.

Over the past ten years, Areas of Concern (AOCs) throughout the Great Lakes Basin have experienced significant progress towards restoring beneficial use impairments. One of the primary factors driving recent success is the federal support provided by the Great Lakes Legacy Act (GLLA) and the Great Lakes Restoration Initiative (GLRI). Enacted in 2007 and in 2010 respectively, the GLLA and GLRI represent significant administrative, financial, and institutional commitments to restoration in Great Lakes AOCs. Under the Great Lakes Water Quality Agreement (GLWQA), the process of developing and implementing Remedial Action Plans (RAPs) for each AOC was initially driven by local stakeholder groups. Local Remedial Advisory/Action Committees (RACs) were successful in identifying root problems facing each AOC and in developing plans for addressing those problems in the original Stage I/Stage II RAP documents. However, without a framework of federal support, many of the initiatives proposed in the RAPs weren't realized for nearly two decades. Since their inception, the GLLA and the GLRI have fostered significant progress towards the development and implementation of the RAPs in New York's remaining five AOCs. Administratively, this included a comprehensive review of the status of each AOC's RAP and the development of distinct delisting strategies. Practically, this has facilitated the successful identification and completion of many significant management actions throughout New York's AOCs. This presentation will highlight recent progress within the Buffalo River and Niagara River AOCs, the two AOCs in New York that are within the scope of the Lake Erie Lakewide Action and Management Plan.

LEHNEN, J., TATATREVICH, S., CLARKE, D., New York State Department of Environmental Conservation. **South Shore Lake Erie Coastal Resilience Data Assessment**.

The implementation of the Nearshore Framework under the Lake Erie Lakewide Action and Management Plan (LAMP) appears to be an evolving endeavor with direct implications on future CSMI priorities and environmental resource program management plans. Coastal data sets which are critical for resilient coastal management and integrated decision making are often limited in their usefulness due to unqualified data, gaps in coverage, variable spatial scales and collection frequencies, and inconsistent collection methodologies. This is especially evident when comparing data sets that span the south shore of Lake Erie and its multiple state and county boundaries. Starting in 2020, NYS DEC Great Lakes Program initiated an inventory of available Lake Erie coastal data and data products which support some of the components of resilience, such as habitat protection and restoration, coastal regulation, science and engineering, and emergency response. The purpose was to better connect data collection needs with sustainable resource management capabilities within New York State's mandated programs. This assessment included an evaluation of similarities and differences in existing data sets related to availability, data format, and spatial scale. During this process, NYS DEC collaborated with neighboring Lake Erie states of Pennsylvania's and Ohio's Coastal Management Programs to identify common data needs, discuss appropriate spatial scales and collection methods/intervals with the goal of developing a coordinated south shore Lake Erie data acquisition plan. While this planning effort is ongoing, some early findings of the assessment identified that coastal condition and resiliency data needed for evaluating Lake Erie's physical, chemical and biological integrity, particularly along the Lake Erie's south shore, is limited in availability to inform agencies' management decisions. Future data collection and assessment efforts are critical to informing resource management, agency decision-making actions, forecasting climate

driven changes within the lake's nearshore framework, and should become integrated into future Annex 10 or LAMP/CSMI priority planning.

LEPAK, R.[1], JANSSEN, S.[2], KRABBENHOFT, D.[2], OGOREK, J.[2], DEWILD, J.[2], TATE, M.[2], HURLEY, J.[2], [1]U.S. Environmental Protection Agency; [2]U.S. Geological Survey Mercury Research Lab. **Exploring the Heterogenous Mercury Sources to Seston Across Lake Erie's Basins and Nearshore**.

Lake Erie (LE) is an ideal setting to examine Great Lakes mercury (Hg) cycling because Hg sources entering LE are more heterogenous relative the other Great Lakes, and LE exhibits a west to east decrease in productivity across three distinct subbasins of increasing depth. Although LE is part of the Great Lakes, this comparatively unique backdrop conceptually results in a span of mercury dynamics that is like the rest of the Great Lakes in the eastern basin of LE and divergent in the central and western basins. Hg stable isotope analyses is an important tool that has revealed the sources of inorganic Hg in sediments and methylmercury (MeHg) in fish from the Great Lakes. However, fish MeHg isotope values are not like sediment Hg isotope values, leading us to explore the lower food web to test whether an alternative Hg source pathway exists that explains sediment-fish Hg disconnect. Plankton are excellent sentinels to capture basin-level MeHg sources to fish because they are short lived, relatively immobile, and bioaccumulation of MeHg into seston drives fish MeHg burden. In this study, we measured Hg isotope values and speciated Hg content in suspended particulate matter (SPM), water, and seston of LE and its tributaries and revealed Hg sources to SPM and filtered water are dissimilar in both tributaries and offshore LE. Offshore LE SPM and plankton resembled atmospheric Hg, not tributary inputs. Using speciated MeHg in seston we calculated δ202MeHg and Δ199MeHg values, which were dissimilar between LE basins and in one site vertically dissimilar. The MeHg in seston accounted for 60 – 70% of the MeHg burden to Walleye with the remainder likely linked to coastal and benthic MeHg production. Hg and MeHg sources across LE are heterogeneous and the continued monitoring of lower food web prey in will provide improved understanding of LE Hg dynamics.

LESHT, B.[1], SCOFIELD, A.[2], BOCKWOLDT, K.[3], [1]GDIT; [2]U.S. Environmental Protection Agency; [3]Oak Ridge Institute for Science and Education. **Lake-wide Measurements of Primary Productivity During the 2019 Lake Erie CSMI Field Year**.

Although measurements of primary production in Lake Erie have been identified as a priority by the Lake Erie Partnership, few lake-wide, seasonal observations have been reported in the literature. To address this need we used the 13C method to measure production at 11 stations across Lake Erie during the Cooperative Science and Monitoring Initiative (CSMI) surveys in May, July, and September 2019. We also measured primary productivity at four of these stations during the spring (April) and summer (August) EPA Great Lakes National Program Office (GLNPO) Water Quality Surveys (WQS). Samples were collected at two depths at each station and incubated for several hours on deck using eight levels of irradiance. We fit the photosynthesis-irradiance curves with the three-parameter Platt et al. (1980) model, and when no photo-inhibition was detected, we used the two-parameter Webb (1974) model. During the May CSMI survey, there was little variation in chlorophyll-normalized production rate with depth, though half of the nearshore stations showed some evidence of photo-inhibition. Nearshore and western basin production was generally higher than offshore production. The distinction between nearshore and offshore stations was less pronounced in July, but photo-inhibition was observed more frequently nearshore, especially in the deeper samples. Nearshore production was higher than offshore in September and photo-inhibition was observed at 9 of the 11 stations. By using the photosynthesis data from all five surveys and estimated clear-sky solar insolation, we calculated time series of vertically integrated daily areal

production at a western basin station (ER91), two central basin stations (ER43 and ER78), and an eastern basin station (ER15). Production was highest in the central basin during the summer WQS, estimated to be 708 mg C m-2 day-1 at ER43 and 784 mg C m-2 day-1 at ER78. Production peaked in July in the western and eastern basins, at 684 mg C m-2 day-1 and 404 mg C m-2 day-1, respectively.

LUDSIN, S.[1], COLLINGSWORTH, P.[2], CURRIE, W.[3], HOFFMAN, J.[4], WATKINS, J.[5], BOLGRIEN, D.[4], BOWEN, K.[3], COTTER, A.[4], HOOD, J.[1], MANUBOLU, M.[1], RUDSTAM, L.[5], [1]The Ohio State University; [2]Purdue University/Illinois-Indiana Sea Grant; [3]Fisheries and Oceans Canada; [4]U.S. Environmental Protection Agency; [5]Cornell University.
Overview of the 2019 CSMI program designed to understand harmful algal bloom & hypoxia impacts on Lake Erie's webs.

During 2019, we conducted an integrative (multi-agency, multidisciplinary) field program to improve our understanding of how harmful algal blooms (HABs) and bottom hypoxia respectively affect western and central Lake Erie's food webs. Herein, we set the stage for several talks and posters that were conducted as part of this effort, which was supported by the Lake Erie Cooperative Science and Monitoring Initiative (CSMI). First, we provide an overview of our 2019 HAB and hypoxia research program, including our primary research goals, key hypotheses, and progress to date. Second, we describe our field sampling design, illustrating how we combined multi-ship synoptic sampling, real-time HAB and hypoxia forecasts, and time-varying, natural gradients in lake conditions to address our research goals and test our associated hypotheses. Third, we briefly discuss the strengths and limitations of our sampling approach. Finally, we briefly highlight the other CSMI talks and posters that will be presented, which offer detailed insights into how HABs and hypoxia can influence Lake Erie's food webs.

LUESSENHOP, A., In-Situ, Inc. **Remote Monitoring, Simplified**.

Telemetry has been around for years and serves many purposes when it comes to collecting environmental data. It provides a means for monitoring environmental conditions from remote sites without wired communication, provides real-time alerting, saves time and money, helps stakeholders make better use of the data their sensors are collecting and much more. Common telemetry options are cellular, radio and satellite, which transmit the data being collected from the sensors to a monitoring station or data management system. Telemetry can be expensive, time-consuming to setup, require solar panels or expensive power options and have a large profile. As environmental monitoring networks continue to expand and needing to access data being collected from remote sites becomes more important, a low-cost and easy to setup telemetry system may provide those the opportunity to take advantage of the benefits to utilizing a telemetered system, that may not have been able to or wanted to do so before. At In-Situ, we have designed and manufactured VuLink, which is a low-cost, simple to setup telemetry system and our newest development in the world of remote monitoring.

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MACDONALD, R., RIDDICK, N.L., Brock University. **Harvesting of wild rice by indigenous people during the Nipissing Flood event in the Erie basin: reconciling geological and archaeological records at the Middle Woodland Fitzgerald Site**.

A sediment core from the small embayment of Cates Creek, between Long Point and the mouth of the Grand River, records changes in the level of Lake Erie beginning with the capture of

drainage from the Upper Great Lakes, in what has been called the Nipissing Flood event. Indigenous inhabitants of this region would have benefitted from the extensive coastal wetlands with agitated water that were ideal environments for wild rice. Abundant plant macrofossils and pollen of this cereal grass in sediments dated in the Cates Creek core around 4800 – 3700 calibrated years ago suggest that harvesting this resource was the raison d'être of the Fitzgerald Site, approximately 7 m above the modern level of Lake Erie and ca. ½ kilometer from the shoreline. The paleoshoreline of Lake Erie around the Middle-Late Holocene boundary, when lake level was approximately 4 m higher, places the site associated with "Non-Meadowood Early Woodland" artifacts (Parker, 1997) on the northeastern shore of a much larger paleo-Cates Creek embayment. However, the span of the Early Woodland Period, 900-0 BC (2850-1950 BP) according to the Ontario Archaeological Society (2021), is inconsistent with paleobotanical evidence of wild rice at the Fitzgerald Site. Lake Erie had fallen to nearly modern levels by 2900 years ago, as a result of erosion of the Lyell/ Johnson Sill, allowing increased discharge through the Niagara River to Lake Ontario, which was recorded in embayments such as Grenadier Pond (McCarthy and McAndrews, 1988). This suggests that the Early Woodland lithic assemblage extends at least 800 years back than previously thought.

MANNING, N., JOHNSON, L. Heidelberg University. **Nitrogen loading trends for several Lake Erie tributaries at multiple temporal scales**.

Understanding nutrient loading patterns at short (seasonal), medium (annual) and long (multi-decadal) time scales is an important piece of any lake management strategy. This is of particular importance in large, eutrophic systems, like Lake Erie, where there are multiple tributaries, and land use and land cover (LULC) differences between the tributary watersheds. While phosphorus loading is generally the focus in Lake Erie, there is a growing interest in the role of Nitrogen as both a limiting nutrient and as a factor in the development of toxins. In this talk we present both short and long-term loading trends in nitrate-nitrite (NO23) for several major tributaries of Lake Erie. We also touch on trends in Total nitrogen (TN), total Kjeldahl nitrogen (TKN) and ammonium (NH4). These rivers are part of the Heidelberg Tributary Loading Program (HTLP), a long term, high frequency water quality monitoring program established in 1969 by Dr. Dave Baker at Heidelberg University, in Tiffin, OH. We used the Weighted Regression on Time, Discharge and Season (WRTDS) to analyze loading trends over multiple time scales. Results indicate that while there is significant discharge-driven inter- and intra-annual variation in nitrogen concentrations and loads, the systems studied are generally trending lower annually. Spring contributions to total load, however, have been trending up recently, particularly in agriculturally dominated watersheds.

MARSHALL, C., WATKINS, J., CONNOLLY, J., RUDSTAM, L., Cornell University. **Lake Erie Temporal Rotifer Community Dynamics of CSMI 2019**.

Rotifers are among the most abundant zooplankton in lakes but are often overlooked, and limited information is available on their seasonal and spatial distribution within the Laurentian Great Lakes. We present data on Lake Erie's epilimnetic rotifer community utilizing samples collected during the bi-national inter-agency effort known as the 2019 Cooperative Science and Monitoring Initiative (CSMI), reporting on temporal trends in community composition, density, and biomass. The April rotifer community was dominated by Notholca and Synchaeta in both abundance and biomass, followed by a May assemblage more evenly represented by Synchaeta, Keratella, Notholca, and Kellicottia. The rotifer community reached a peak density of ~650/L in July, primarily dominated by Conochilus (477/L) and Polyarthra (114/L). The greatest generic-level diversity occurred during August, when 20 different genera were identified, contributing to a total rotifer

density of 236/L, primarily comprised of Polyarthra (102/L) and Conochilus (68/L). In September, Polyarthra continued to rise (179/L) and Conochilus was similar (90/L), while Keratella densities increased considerably from August (17/L) to September (159/L). Comparisons among rotifer communities collected during GLNPO (April/August) and CSMI (May, July, September) events were also explored to determine the extent with which the long-term data represents the Lake Erie community during a growing season. Efforts were made to determine the environmental factors affecting rotifers during the year, with a focus on differences among basins, such as the shallow eutrophic conditions found in the western basin, the meso- to eutrophic conditions found in the often-anoxic central basin, and the deeper more meso- to oligotrophic conditions of the eastern basin. Additionally, comparisons were drawn between similar research conducted on the Lake Ontario rotifer community during 2018.

MATHIE, D., MOORE, H., HOOD, J., Ohio State University. **Phosphorus cycling during high flow events in the Maumee River watershed: A Lagrangian analysis**.

Since the early 2000's, Lake Erie has experienced re-occurring harmful cyanobacteria blooms which are primarily driven by phosphorus (P) loading from the western basin's agriculture-dominated watershed. Management of these cyanobacteria blooms requires a clear understanding of P sources and sinks within this watershed; however, we have a limited understanding of how ditches, streams, and rivers influence the magnitude and bioavailability of P exports to western Lake Erie. Over eighty percent of these P loads occur during high flow events; making it crucially important to understand P cycling during high flows. To better understand P cycling during high flow events, we used a Lagrangian approach to characterize longitudinal patterns in P dynamics between dissolved and sediment-bound P during a storm event in spring 2021. We used a swarm of GPS trackers to follow a parcel of water as it moved along a 15 km river continuum from the Blanchard River headwaters to its mainstem. At 11 stations, we measured dissolved and sediment-bound P, while at six stations we also measured equilibrium P concentration and P sorption-desorption rates. We will discuss longitudinal patterns in dissolved and sediment-bound P concentrations and examine how rapidly P cycles between these fractions during downstream transport. Our results will improve our understanding of P cycling during high flow and contribute information to watershed-scale P management.

MCCABE, K.[1], ANDERSON, H.[1], BURTNER, A.[1], KITCHENS, C.[1], CAMILLERI, A.[1], JOHENGEN, T.[2], GODWIN, C.[1], [1]The Cooperative Institute for Great Lakes Research; [2]Michigan Sea Grant. **Distribution of Phosphorus and Nitrogen with Respect to Seasonal Hypoxia in Lake Erie's Central Basin**.

Seasonal hypoxia in the central basin of Lake Erie is exacerbated by excess nutrient inputs. Consequently, this seasonal hypoxia alters the cycling and removal of the nutrients, particularly phosphorus (P) and nitrogen (N). Hypoxia in the basin was first linked to changes in nutrient cycling, most notably the release of P from the sediments, in 1960-1970s; however, due to a lack of routine N and P monitoring in the hypolimnion during hypoxia, the dynamics and extent of these alterations remain unclear half a century later. As part of the 2019 Cooperative Science and Monitoring Initiative, we measured the vertical distributions of total P, total dissolved P, soluble reactive P (SRP), nitrate+nitrite, ammonia, and particulate P and N before, during, and after hypoxic conditions. We found elevated P, especially SRP, during the late summer with the onset of anoxic conditions: first along the perimeter of the stratified areas and later in September across the bottom waters of the central basin. Elevated P concentrations were measured throughout the water column after turnover. Conversely, dissolved inorganic and particulate N concentrations remained fairly constant across normoxic, hypoxic, and anoxic conditions. Our findings corroborate findings of

recent sediment core incubation experiments and further highlight the ubiquity of internal P loading across the central basin as a result of anoxic conditions. These results further our understanding of the effects of seasonal hypoxia on biogeochemical cycles and can inform eutrophication management.

MCCARTHY, F., RIDDICK, N.L., MACDONALD, J.R., Brock University. **The State of Lake Erie 4,000 years ago-geological & archaeological evidence**.

The mean level of Lake Erie was approximately 4 m higher around 4,000 years ago, as drainage from the Upper Great Lakes was transferred to the St. Clair- Detroit Rivers from the earlier Mattawa - Ottawa River outlet. Indigenous inhabitants of coastal Lake Erie would have benefitted from extensive wetlands with agitated water that were ideal environments for wild rice during this 'Nipissing Flood' event that spanned several centuries Erie around the Middle-Late Holocene boundary. Harvesting this resource was presumably the raison d'être of the Fitzgerald Site, associated with "Non-Meadowood Early Woodland" artifacts (Parker, 1997). This unassuming site is approximately 7 m above the modern level of Lake Erie and ca. ½ kilometer from the modern shoreline on the Haldimand Clay Plain. The Early Woodland site would have been on the northeastern shore of a much larger paleo-Cates Creek embayment when abundant plant macrofossils and pollen of this cereal grass were found in sediments dated around 4800 – 3700 calibrated years ago (Pengelly et al., 1997). This virtual tour will examine evidence of occupation of the Fitzgerald Site and questions archaeological estimates of its age, since it would been far from the Lake Erie shoreline following the sharp decline in lake level attributed to erosion of the Lyell/ Johnson Sill around 2900 years ago. Extensive wild rice-hosting wetlands had long disappeared from this region by the latest reported dates for Early Woodland lithic assemblages, suggesting that this culture extends nearly a millennium earlier than previously thought (MacDonald et al., this conference).

MCKINNEY, P., HOLLENHORST, T., ALSIP, B., HOFFMAN, J., U.S. Environmental Protection Agency. **Autonomous underwater glider operations during CSMI 2019**.

We deployed an autonomous underwater glider in Lake Erie's central basin from September 5 to September 27, 2019 to investigate the spatial and temporal extent of hypoxia. This was the first deployment of an expected multiyear effort using gliders to examine factors affecting water quality in Lake Erie. The glider repeated a nearshore-to-offshore pattern near Cleveland, OH that included passing near two buoys that provided meteorological data and vertical profiles of temperature and dissolved oxygen for comparison. The glider detected the hypoxic bottom layer across the entire survey region, demonstrating autonomous gliders can successfully operate near the bottom of a lake in water depths of less than 25 meters. However, unexpected fouling of the glider's optical sensors affected data quality after the first two weeks. This presentation will review lessons learned and suggested modifications to standard programming, maintenance, and calibration protocols for successful glider operation in the shallowest Great Lake.

MEIRI, G., IOSight. **Utilizing data analytics to detect pollution in watersheds and river basins and support timely event response**.

According to the most recent surveys on national water quality from the U.S. Environmental Protection Agency, nearly half of US rivers and streams and more than one-third of US lakes are polluted and unfit for swimming, fishing, and drinking. Surface water quality risks arise from various sources including: industrial and mining activity, agricultural activity, wastewater systems and treatment, and households. Contamination, as well as the impact of the various measures implemented to reduce it, require effective monitoring based on reliable and precise data analysis. A

comprehensive data-driven surface water quality monitoring framework should utilize real-time and other types of data to support decisions related to the prevention, detection, and mitigation of contamination events. A good example of a robust data-driven surface water quality monitoring program can be found in iShed, a predictive analytics solution co-developed by Mekorot, Israel's national water company, and IOSight, a provider of water-specific data analytics solutions. iShed was developed to protect Israel's main source of surface water – the Sea of Galilee – from various contamination risks. iShed has been operational since 2017. It includes several key attributes: integration of data from a variety of sources (real-time sensors, weather, lab samples), algorithm-based formulation of integrated water quality indexes, early detection and alerts related to pollution events, while eliminating virtually all false alerts, and calculations of contamination propagation downstream. iShed is currently being implemented by a major US water entity and some of the functionality has been implemented in the Chicago River as the data management and analytics solution embedded in the H2Now Chicago real-time water quality monitoring program. The session will provide an overview of surface water quality challenges and presentation of iShed – an innovative predictive analytics solution, developed and utilized to provide reliable real-time pollution detection and speed of propagation.

MENDONCA, R., Kent State University. **Developing Integrated and Continuously Updated Data Infrastructure for heterogenous wetland monitoring data**.

Data generated by long-term environmental monitoring are extremely valuable, but its complexity poses a challenge to data and quality management. As the H2Ohio Wetland Monitoring Program obtain over 50 wetland projects under its umbrella, it has been developing a custom database design to accommodate the sundry sources, formats, and workflows of data acquisition within the program. Some of the challenges we are iteratively addressing include: 1) centralize data that is collected by and initially housed at 6 different institutions, 2) implement consistent collection and distribution workflows across water, soil, and vegetation samples, geophysical, hydrological, and drone measurements, and field-collected data from handheld probes and deployable sensors, 3) properly document and index sample metadata and corresponding analytical data, along with easily accessible sample chain-of-custody, 4) assure quality of raw and processed data analyzed and manipulated by different analytical instruments, software, and methodology, 5) store and backup data of all kinds and scales generated by the Monitoring Program in a searchable manner, and 6) make data that meet quality standards readily available to researchers and stakeholders. We have implemented the use of ArcGIS Field Maps mobile application to ensure proper metadata entry, completeness, unique sample identification, and accurate location in the field. Automated workflows have been developed with Python scripts to export ArcGIS Online data daily as a local backup and integrate the data into GitHub for version control. A continuous integration system established in GitHub Actions runs quality control checks on the newly imported data and, upon success, appends the data to our database. Database queries will allow program-wide users to retrieve the data for downstream analysis. Full access of verified data to researchers and stakeholders is still under development, along with beta testing of our current workflows.

MICHEL, F., Ohio State University. **Use of Composts to Improve Nutrient Retention and Provide Slow Release Crop Fertility for degraded soils in the Lake Erie Watershed**.

Decades of industrial agriculture practices throughout our country have left much of today's farm field soils depleted of essential soil components critical to healthy environmentally protective soils. Today while all the attention is focused on fixing the health of Lake Erie by targeting nutrient laden water, we challenge conventional thinking to instead focus on fixing the soils. Depleted soils can serve as the most impactful solution to Lake Erie's water quality crisis simply by focusing on increasing the depleted soil organic matter content of Ohio farmlands. Compost based soil amendments have the potential to improve the ability of soils to retain nutrients by increasing soil organic matter and water holding capacity. It also provides slow-release fertility to crops that can displace more mobile chemical fertilizers. To offer an added benefit the path to implementing this solutions can be found right here in Ohio's western basin simply by reevaluating the way that we currently handle livestock waste. The Lake Erie watershed generates large amounts of manure and both urban and agricultural crop residues that could be used to create composts and high organic matter soil amendments, that reduced nutrient mobility through a variety of mechanisms. In this presentation we will discuss a strategy for creating and distributing compost and compost based products within the Lake Erie watershed to achieve these benefits. Decades of extensive research suggests that a high organic matter soil amendment made from composted yard trimmings, manure, biosolids and other organic waste streams, will improve water holding capacity, increase soil organic matter thereby improving nutrient retention, particularly phosphorus. Use of compost in the material will provide long term, bound nutrients, reducing the requirements for synthetic fertilizer or manure application which both have high run-off potentials, and reduce the impacts of crop production on Lake Erie. A strategy to demonstrate how this approach can easily and immediately be implemented and the dramatic impact on the watershed it can provide will be presented.

MILLS, M.[1], ISOM, K.[1], GIANCARLO, M.[1], WALTERS, D.[2], PELKA, A.[1], CIENIAWSKI, S.[1], [1]U.S. Environmental Protection Agency; [2]U.S. Geological Survey. **10 Years Post-Remediation Progress Evaluated and Impacts on Restoration in the Ashtabula River Area of Concern**.

Background/Objectives: The first Remedy Effectiveness Assessment (REA) of its kind was created to assess the effectiveness of the Great Lakes Legacy Act (GLLA) sediment remediation project that took place in the Ashtabula River Area of Concern (AOC) in Ohio from 2006 to 2007. The GLLA project footprint spanned 1.2 river miles of the channel near the river mouth. The Great Lakes National Program Office (GLNPO) of the U.S. EPA partnered with nonfederal sponsors to implement the removal of approximately 500,000 yds3 of sediments contaminated primarily with PCBs. The REA analyzed paired data taken pre- and post-remediation along multiple lines of evidence to assess how effective the dredging project was in meeting its remedial objectives. This presentation evaluates data used to calculate the 10-y post-dredge surface weighted average concentrations (SWACs) in both the 2006-2007 GLLA project area and overall AOC, impacts on the status of beneficial use impairments (BUIs) in the AOC, and overall progress on AOC delisting and restoration efforts. Results/Lessons Learned: The REA concluded that the 2006-2007 GLLA remedial action met its project objectives and resulted in improvements in the surrounding aquatic environment. The long-term SWACs demonstrate that significant PCB contamination has been removed from the system, and the removal of several BUIs from the AOC demonstrate that the 2006-2007 GLLA project set the foundation for future restoration and delisting of the AOC. Careful selection of parameters used to evaluate remediation effectiveness is key to allow for direct comparability of the data. Baseline SWACs were calculated using PCB homologues, while the 10-y post-dredge SWACs utilized PCB Aroclors. Another key consideration is determining the

appropriate geographic scale for data collection and interpretation. Understanding the distinction between the GLLA project area and the extent of the entire AOC is a key consideration when evaluating project-specific impacts on BUIs and overall remediation effectiveness.

MILTNER, R., Ohio Environmental Protection Agency. **MONITORING FOR AGENCY: CONSIDERATIONS FOR DEVELOPING AN EFFECTIVE CITIZEN SCIENCE PROGRAM**.

Various governmental bodies are delegated responsibility to manage and protect the quality of water as it moves through the hydrologic cycle. Water quality monitoring provides the data necessary to know the status of waters and to inform management decisions. Because the hydrologic cycle is continuous, and monitoring is temporally and spatially discrete, the knowledge of status is inherently incomplete. Furthermore, water quality is affected by chemical, physical and biological processes, as well as anthropogenic stressors, and monitoring designed to capture all processes and stressors over broad or complete spatial scales is not practical. An understanding of how monitoring is organized and the capabilities within that structure identifies gaps that a citizen-led monitoring can potentially fill. Perhaps more crucially, for monitoring data to be useful, whether collected by professionals or citizens, certain standards for collecting, measuring and reporting need to be met. This presentation discusses efforts underway to help citizen-based monitoring groups or local champions understand and implement data quality standards within the broader context of water quality monitoring as a whole.

MILTNER, R.[1], WINSLOW, C.[2], FUSSELL, K.[2], [1]Ohio Environmental Protection Agency; [2]Ohio State University. **Defining and Establishing an Aquatic Life Use for Lake Erie**

Lake Erie is volumetrically the 15th largest freshwater lake on the planet. It is the shallowest, warmest, and most productive of the Great Lakes. Given its size and productivity, the aquatic life in Lake Erie yields considerable economic and social benefits. The Clean Water Act calls for waterbodies to be designated for beneficial uses, aquatic life being one of those uses, standards established to protect those uses, and assessment methods to evaluate if uses are being met. If a use or a standard protective of that use is not being met, management actions are initiated as a remedy. To date, an aquatic life use appropriate for Lake Erie has not been adopted. The aquatic life in the lake is a manifestation of a large system with interconnected parts. These parts are both biological and environmental. Thus, measuring aspects of aquatic life that are either themselves an integral systems component or directly dependent on the functioning of an environmental component will return information on the status of the aquatic life use. Similarly, measuring key environmental components that directly impact or govern aquatic life also provide information on that status. Overall attainment of the use designation is determined by the collection of relevant measures and their respective benchmarks. Because Lake Erie is a large system, it is possible for an individual component to be impaired or in a suboptimal condition without causing the overall system to be impaired; however, that does not obviate the need to redress a failing component. The Ohio Environmental Protection Agency has convened a panel of system experts to identify the relevant measures and benchmarks necessary for assessing aquatic life in Lake Erie. The measures and rationale for those measures are herein described. Benchmarks for the respective measures in some cases have been previously established, while others are a work in progress, and the subject of ensuing presentations in this session.

MIRZA, R., WAGER, Y., Wayne State University. **Fate and Transport of Microplastics in the Detroit River Originating from the Detroit Wastewater Treatment Plant**.

Microplastic pollution in water bodies is an emerging environmental concern. Many studies have focused on marine ecosystems, while freshwater ecosystems have received attention recently. Microplastics released into freshwater are studied to better understand the fate and transport of microplastics within freshwater ecosystems and from freshwater to the marine environment. This research aims to fill the knowledge gap by examining the fate and transport of microplastics in the Detroit River released from the Detroit Wastewater Treatment Plant (WWTP) by using a combination of modeling tools and microplastics survey in wastewater and the receiving water. Mike 21 Flow Model in conjunction with Hydrodynamic module and Agent-Based Modelling Lab module were used. Data was collected for water levels, mean water velocity, and wind speed and direction for the Detroit River at two stations near the north and south boundaries of the study area. These modules were utilized to simulate the hydrodynamic conditions and the movement of microplastics in the Detroit River originating from the Detroit WWTP outfall discharge point. This work led to understanding the spatial and temporal distributions of microplastics in the studied area of the Detroit River. Scenarios took into consideration the different sizes and densities of microplastics detected from the Detroit WWTP. Considering that the Detroit River is flowing to Lake Erie, understanding the fate and transport of microplastics in the Detroit River will help microplastic mitigation initiatives in these critical freshwater resources.

MOORE, H., HOOD, J., Ohio State University. **Influence of temperature and nutrients on primary production and phytoplankton biomass in western Lake Erie**.

Since the early 2000's, western Lake Erie has experienced reoccurring harmful cyanobacteria blooms (cyanoHABs), which have had negative effects on local economies, human health, and the Lake Erie ecosystem. Thus, it is important to understand the patterns of and controls on the growth and mortality of cyanoHABs and more generally phytoplankton. It is well recognized that the most important determinants of phytoplankton growth and dynamics are often phosphorous, nitrogen, and temperature; however, our understanding of how these factors interact to influence the growth and dynamics of cyanoHABs and other phytoplankton groups in situ has been impeded by methodological constraints associated with the need to characterize phytoplankton growth and physiochemical controls in labor-intensive microcosm experiments. To better understand how temperature and nutrients interact to influence the dynamics of cyanoHABs and other phytoplankton, we couple physiochemical monitoring data with in situ measures of ecosystem metabolism (primary production and ecosystem respiration) estimated using the free-water method. Ecosystem metabolism plays an important role in shaping lake carbon cycles, energy movement throughout food webs, and is intrinsically linked with cyanoHAB growth and dynamics. Using physiochemical monitoring data from five buoy stations located in the western basin of Lake Erie, we estimated ecosystem metabolism during May-October 2017. Gross primary production was generally higher at sites near the Maumee River mouth and was positively correlated with both chlorophyll a concentration and temperature. Our preliminary data analysis, suggests a positive correlation between gross primary production and lake water nitrate, but not phosphate, concentrations. We will discuss how temperature, nutrients, and their interactions influence gross primary production and phytoplankton dynamics. Our results will improve our understanding of how the physiochemical environment influences phytoplankton and cyanoHABs growth and development and, hopefully, contribute to the improvement of cyanoHAB forecasting and management efforts.

MURDUCK, D., Champion Middle School. **Equity in Teaching Students the Importance of the Great Lakes**.

Encouraging all students to become actively engaged in protecting the multiple resources provided by the Great Lakes is important. This presentation will expose you to ways that will inspire students to want to protect Lake Erie and the adjoining watershed. Learn how Champion students raise and release rainbow trout, complete stewardship projects that support the Great Lakes Restoration Initiative, and learn how the entire Great Lakes watershed is connected from a variety of lessons. Whether gathering macroinvertebrate and water quality data at Swine Creek park or listening to the Ohio Fish Hatchery Superintendent as part of our after school speaker's bureau, students are exposed to multiple aspects of environmental science. In addition, from restoring wetland native species at our Outdoor learning Lab to spending 3 nights and 4 days on a trip focused on studying Great Lakes ecosystems, multiple students are given the opportunity to have amazing learning experiences. Furthermore, all stakeholders in Champion have become supporters and active participants in the environmental education programs our school provides. Join me and learn how baby steps are key to your success!

N

NEELON, D., Northeast Ohio Regional Sewer District. **Communicating Water Quality and Promoting Environmental Stewardship**.

Each year, the Northeast Ohio Regional Sewer District (NEORSD) works on two campaigns to reach the community at the intersection of environmental stewardship and public health. Year round, the Pick-Up-Poop (PUP) Program encourages the responsible disposal of pet waste to prevent bacteriological contamination of stormwaters. Along with posted information about the importance of proper dog waste disposal, residents are encouraged to participate by placing District signage in their yards. By spreading awareness of how individual action can impact local water quality, citizens become active agents in pollution prevention. During the summer, the daily Beach Monitoring Program monitors East and West Side beaches and communicates the current bacteriological and algal conditions of the nearshore bathing waters. The beach report is sent to our partners at the Cleveland Metroparks, the Ohio Department of Health, iHeartMedia, and WKYC Channel 3. Data is also posted online to several beach water quality resources. Additionally, our social media team operates a dedicated Beach Twitter Account. By utilizing both traditional signage as well as news and social media, beachgoers have easy access to water quality data. Connecting individual actions to the bacteriological quality of the beaches and local streams, these two programs help our customers see their own roles in pollution prevention and the importance of protecting Lake Erie Shores.

NEWELL, S.[1], HOFFMAN, D.H.[2], MCCARTHY, M.J.[1], GONZALEZ-BOY, K., MYERS, J., [1]Wright State University; [2]Kennesaw State University. **Nitrogen availability as a driver of HABs and toxins: the missing piece for modeling?**

External nutrient loading (along with temperature and precipitation) is the main driver of annual harmful algal blooms in Lake Erie. These blooms are dominated by the cyanobacteria Microcystis, which produces microcystin toxins, but toxicity and biomass are not always correlated and can vary from year to year and within a season. Microcystis is an excellent scavenger for ammonium and can outcompete other organisms for this preferred ammonium supply. Ammonium is therefore both taken up by cells and recycled rapidly in eutrophic systems, making it difficult to determine availability snapshot concentration measurements. Studies on ammonium turnover rates

in the water column of Lake Erie, as well as supply from sediments, suggest that internal loading is a critical component of sustaining bloom biomass. Using ammonium recycling rates in mixed models also results in strong models for concentration of microcystins (R2 =0.84 or better), suggesting that ammonium availability might be key for modeling and predicting bloom toxicity.

O

OGOREK, J.[1], LEPAK, R.[2], DEWILD, J.[1], TATE, M.[1], ROSERA, T.[1], HURLEY, J.[3], HOFFMAN, J.[2], KRABBENHOFT, D.[1], JANSSEN, S.[1], [1]U.S. Geological Survey; [2]U.S. Environmental Protection Agency; [3]University of Wisconsin, Madison. **An Exception Among Giants: Why Mercury Cycling in Lake Erie Differs from the other Great Lakes**.

The USGS Mercury Research Lab has conducted ambitious sampling campaigns (2010-present) across the Great Lakes. To date, we have visited over 200 sample sites (tributaries, nearshore, and pelagic waters) that encompass numerous matrices and thousands of data points all with the goal of understanding the nuances of mercury (Hg) cycling and bioaccumulation within the system. Our most recent work offers a view of Hg in water and subsequent uptake into plankton across the Great Lakes. We found that aqueous Hg concentrations are relatively similar across all the Great Lakes and that biological uptake rates fit our conceptual paradigm; however, Lake Erie is an exception. We proposed that these divergences in Hg cycling observed in Lake Erie are due to the unique chemical, hydrological, and ecological factors present in the lake. In support of a continued and detailed sampling effort on Lake Erie, here we report Hg results across Lake Erie in heightened detail, compare those results across Lake Erie and to the other Great Lakes, and highlight anomalies and unexpected similarities when they exist. Unfiltered total mercury concentrations in the Lake Erie Central/Eastern basins were very low (0.2 ng/L) and similar to the extremely oligotrophic and pristine Lake Superior while total mercury in the Western basin was an order of magnitude higher and highly variable. We did not measure elevated mercury in the hypolimnetic waters of Lake Erie, despite having comparatively elevated sediment mercury, indicating a lack of benthic mercury flux. Methylmercury concentrations in size-separated plankton from Lake Erie were also the lowest among the Great Lakes (< 10 ng/g) and only modestly increased with increasing size. These results are anomalous in the greater context of the Great Lakes, especially considering Lake Erie's increased productivity, seasonal hypoxia, toxic algae blooms, and a contaminants legacy that includes unchecked industrial discharges.

OGUNDEJI, S., BECKER, R., BARTLETT, T., University of Toledo. **Object-Based Classification of Unmanned Aerial Vehicle (UAV)/Drone Imagery to monitor H2Ohio Wetlands**.

Remote sensing observations from Unmanned aerial vehicles (UAVs) were used to map and monitor the spatial and temporal distribution of landcover at wetlands that are part of the H2Ohio program. These wetlands were designed for increased nutrient reduction in the Maumee watershed in Northwest Ohio. Object-based classification techniques are used to classify landcover on the wetland and differentiate between vegetation types. This approach allows us to quickly map the vegetation cover and variability over these reconstructed wetlands projects. High-resolution UAV infra-red (NIR) and visible images of the study sites were acquired. These were geometrically and radiometrically corrected to generate Orthomosaics, Digital Elevation Models, and Normalized Difference Vegetation Index (NDVI) images. These products were combined and then segmented into homogenous units(objects) based on the similarities in shape, scale, color, smoothness, texture, etc., using E-cognition. Derived segments (objects) were selected as training samples. Object-Based

classifiers including Support Vector Machine (SVM) and Random Forest (RF) were used to predict the classes of the sites from the trained samples. Each class represents a particular vegetation species or other landcover (like waterbody, bare ground, etc.) present on the wetland. After this, the classification model results will be compared with field validation data to test if it can accurately predict the established classes. This process will be repeated on a temporal basis to observe the vitality and abundance of the plant community hence monitoring the effectiveness of the wetland in the absorption of nutrients. The final results will be compared with data from geophysical, soils, and vegetation observations to see if: a) the homogeneity derived from the classification is also observed by other scientists who carried out in-situ measurements b) there is a correlation with the subsurface and other physical, cultural or biological features in the area.

P

PANOZZO, K., RAHMAN, I. CZAIJKOWSKI, K., APARDIAN, R., University of Toledo.
Mapping Conservation Practices to Evaluate Water Quality Benefits in the Maumee River Watershed.

This work is part of a larger project collaboration between the University of Toledo, Ohio State University and the USDA Agricultural Research Service aimed at guiding the H2Ohio program with projections of conservation practice effectiveness in the Maumee River watershed. The project will use field-to-watershed scale geospatial analysis and hydrologic modeling to simulate the water quality benefits that can be expected from recent and future adoption of the 'top ten' H2Ohio practices by; (1) mapping existing conservation and management practices in the Maumee, (2) improving field-scale watershed model of the Maumee River watershed with emerging data, and (3) evaluate and provide guidance on water quality benefits of the H2Ohio practices and program. The first objective builds upon previous work completed through the ODHE HABRI grant "Effectiveness in Implementation – Mapping Agricultural Management Practices, Farmer Perceptions and Outcomes" in which remote sensing and GIS tools are used to identify and map cover crops, tillage practices, crop rotation patterns and filtration strips for 2017. Three sub watersheds were evaluated for 2017 and we expand this work to identify practices within the entire Maumee River watershed for multiple years. We use high-resolution (<1 meter) remote sensing and Landsat imagery to derive practices for a baseline period (2008), pre-H2Ohio (2017), and post-H2Ohio (2022).

PARENT-DOLINER, G., Water Rangers. **Stronger Together: Spotlight on Lake Erie Guardians**.

This presentation introduces the Lake Erie Guardians (LEG) program: a community based water monitoring project undertaken by Water Rangers and Freshwater Alliance in 2021. Our organizations are dedicated to protecting Canada's freshwater and empowering people with tools to connect with water, and with science. In 2021 we put out a call for people to join the program, to help keep an eye on the health of the Lake Erie watershed. We equipped 50 Western Ontarians with the Water Rangers' freshwater teskits. We provided virtual training and both the digital and physical tools they needed to get outside monitoring water, all in a bid to protect and enhance local waterbodies in the Lake Erie watershed. The presentation will review the activities and impact of the Guardians' program. We'll report on the hundreds of water quality observations they collected, which were then shared openly on digital platforms, including the new Great Lake DataStream. Guardians were also challenged to partake in activities for their watershed, which saw hundreds of trees and wetland plants for restoration go into the ground, truth and reconciliation

challenges, invasive and nuisance species recognition, and regular trash collection efforts along shorelines. Ultimately these community scientists renewed their connections to water and contributed in deep and impactful ways to the protection and restoration of Lake Erie. The program exceeded all expectations and was extremely successful. We'll speak to the exciting collaborations and networks formed by this undertaking, as well as our plans to grow the guardians' program in the coming years in different Great Lakes' watersheds and beyond. We'll also speak to how we met the challenges of connecting with and supporting the Guardians during the pandemic.

PARKER, A., Michigan Department of Environment, Great Lakes, and Energy. **Before reaching the big lake: cyanobacteria blooms in Michigan's inland lakes**.

While the annual cyanobacteria blooms in western Lake Erie have received much attention, less is known about inland lake blooms. Since 2016, a multi-agency collaboration within Michigan has been working on tracking and responding to cyanobacteria blooms in inland lakes that are primarily reported by citizens. From 2016 - 2020, 125 different waterbodies in Michigan have been documented as having confirmed cyanobacteria blooms. Over half of those waterbodies were either reservoirs or natural lakes with dams at their outlets. Given that only around 11% of Michigan's inland lakes that are greater than 5 acres in size are reservoirs, or natural lakes with dams, those lake types seem to be over-represented amongst waterbodies that have experienced cyanobacteria blooms. Further analysis found that reservoirs tend to be shallower and have higher shoreline development factors, which may be conducive to bloom formation. Even though only a small part of the State of Michigan is in the Lake Erie watershed, a disproportionate amount (28%) of the inland lakes where cyanobacteria blooms have occurred have been in that watershed. This is likely because of a combination of factors including a large density of lakes in that watershed and land uses ranging from intense agriculture to densely populated, urban areas. In recent years the Michigan Department of Environment, Great Lakes, and Energy has listed some inland lakes as impaired and has prioritized watershed management plans and best management practices in the Lake Erie watershed to reduce nutrient run off.

PARSONS, C., COSTA, D., CREVOCOEUR, S., REID, T., BLUKACA-RICHARDS, A., Environment and Climate Change Canada. **Assessing the impact of continuous cover on biogeochemical cycling and stream health in Lake Erie headwaters**.

The Living Laboratory Initiative (LLI) was launched by Agriculture and Agri-Food Canada to provide an integrated approach to agricultural innovation, bringing farmers, scientists, and other partners together to co-develop, test, and monitor agricultural best management practices (BMPs) and new technologies in a real-world context. The Lake Erie Basin was identified as a priority for the Ontario LLI, and continuous cover was selected as a BMP of broad interest within the basin. Continuous cover affords a multitude of well-demonstrated benefits, both agronomic and environmental, and has been extensively adopted within the Canadian Lake Erie watershed. Particularly, decreases in soil erosion and the export of nutrients have been well documented at the edge of field. However, empirical evidence for the influence of continuous cover on the export of soil, carbon and nutrients at the watershed scale is lacking. Further, the potential influence of adaptations to agricultural production systems to incorporate continuous cover on the diversity, structure and function of microbial communities in headwater streams has not been thoroughly explored. Therefore, the extent to which water quality and stream health benefits propagate downstream remains uncertain. We have implemented a paired study design to compare watersheds with high adoption of BMPs, to those with low adoption of BMPs in geographically similar regions. Three pairs of watersheds were selected representing a range in physiographic characteristics and agricultural production systems within the Canadian Lake Erie watershed. Watersheds were also

selected based on the ability to leverage established watershed monitoring sites/projects and historical data. Water chemistry, discharge and agricultural practices are being monitored year-round in each of the selected watersheds, in partnership with the local conservation authorities. Simultaneously, the diversity, structure and function of microbial communities within stream-bed sediments are being evaluated in an effort to investigate changes to stream health, nutrient metabolism or detoxification pathways. These combined datasets are further being used to inform the development of a novel mechanistic mathematical model incorporating realistic representations of cold weather hydrological and biogeochemical processes. An overview of our approach and progress to date will be presented.

PETERS, D.[1], COLLIS, L.[1], SHAW, M.[1], SLAGLE, Z.[2], VANDERPLOEG, H.[3], HOOD, J.[1], [1]Ohio State University; [2]Ohio Department of Natural Resources; [3]NOAA Great Lakes Environmental Research Laboratory. **Zooplankton Grazing on Picoplankton and Nanoplankton During Harmful Algal Blooms**.

The western basin of Lake Erie has experienced a reemergence of harmful algal blooms (HABs), with significant socioeconomic and ecological consequences. However, the effect of HABs (primarily blue-green algae also known as cyanobacteria) on aquatic food webs remains poorly understood, in part, due to a lack of information about grazing by zooplankton on phytoplankton during these events. Mesozooplankton can be an important energetic link between primary producers and higher trophic levels; however, the cyanobacteria which dominate HABs are generally considered less edible and nutritious for many mesozooplankton taxa and, therefore may slow energy transfer through food webs. To better understand zooplankton grazing rates and selectivity, we examined zooplankton grazing and selectivity for smaller, and likely more edible picoplankton (0.2–2 μm) and nanoplankton (2–20 μm) during cyanobacteria blooms. We quantified grazing by mesozooplankton on picoplankton and nanoplankton using gradient grazer assays on two dates during a cyanobacteria bloom in the western basin of Lake Erie. On each date, we manipulated zooplankton densities and measured the change in nano- and picoplankton over a 24-hour incubation period via epifluorescence microscopy after staining with DAPI (4',6-diamidino-2-phenylindole). We also measured the biomass of autotrophs and heterotrophs within each size fraction. We then estimated grazing rates for autotrophic and heterotrophic nanoplankton and picoplankton and determined zooplankton selectivity for each group. Our results will help clarify patterns of energy flow between phytoplankton and zooplankton in this large lake ecosystem, enhancing our ability to predict how food webs and ecosystem-level processes are influenced by HABs.

PICZAK, M.[1], BUSCH,K.[3], DILLON, R.[4], BUDNIK,R.[5], COLLINGSWORTH,P.[4], CURRIE,W.[6], HOFFMAN,J.[7], WATKINS,J.[2], BOLGRIEN,D.[7], BOWEN,K.[6], COTTER, A.[7], HOOD, J.[5], MANUBOLU,M.[5], RUDSTAM, L.[2], [1]Carleton University; [2]Cornell University; [3]Miami University; [4]Purdue University; [5]Ohio State University; [6]Fisheries and Oceans Canada; [7]U.S. Environmental Protection Agency; **Harmful algal bloom effects on fish habitat use and community structure within Lake Erie**.

Harmful algal blooms (HABs) consisting mostly of the cyanobacteria Microcystis aeruginosa have been increasing in frequency, duration, extent, and intensity in freshwater ecosystems worldwide, yet our understanding of their impact on aquatic food webs remains limited. Towards providing ecological understanding that could benefit fisheries management in freshwater ecosystems experiencing HABs, such as Lake Erie, we conducted daytime and nighttime hydroacoustic surveys and trawling (mid-water and bottom) inside and outside of blooms in the western basin during July-August 2019. Here, we report on the degree to which fish predators and

their prey use blooms. We hypothesized that small-bodied, planktivores preferred as forage by Lake Erie walleye (e.g., age-0 gizzard shad Dorosoma cepedianum; rainbow smelt Osmerus mordax; shiners, Notropis spp.) would exhibit a diel shift in bloom use, with individuals using the turbid blooms during the day as refuge and avoiding them during the night, owing to high cyanotoxin levels. We also hypothesized that larger-bodied piscivores (e.g., age 1+ walleye Sander vitreus) would avoid HABs entirely (i.e., day and night) due to impaired foraging conditions cause by low light levels and biogenic turbidity. Preliminary trawl results offer some support for our hypothesis concerning prey; catches of small-bodied, planktivores during July were about higher in blooms during day than at night, with opposite catch trends being observed in non-bloom areas (seemingly due to movement out of the blooms at night). We expect ongoing analyses of the hydroacoustic data to shed more insight into the robustness of this diel movement pattern, as well as help us understand the use of HABs by large-bodied predators and other components of the fish community (e.g., benthic-feeding fishes), which could help Lake Erie fishery managers better understand the impact of blooms on their valued fisheries.

POZEGA, N., St. Clair Region Conservation Authority. **An Update on the Status of the St. Clair River Area of Concern (Canada)**.

In 1987, the St. Clair River was identified as one of 43 Great Lakes Areas of Concern due to severe degradation of the aquatic environment. As a result, a Remedial Action Plan was developed to address point-source and non-point source pollutants, and to restore beneficial uses of the river which had been deemed "impaired". Through the implementation of this plan, the condition of the river has improved, and many beneficial uses have been restored, but work continues today. This presentation will touch on the history of the St. Clair River and the activities which led to its degradation, highlight the recent remedial actions completed along the Canadian shores of the river, and identify the next steps to address the remaining beneficial use impairments (restrictions on fish and wildlife consumption, degraded fish and wildlife populations, degradation of benthos, restrictions on drinking water consumption, and loss of fish and wildlife habitat).

PROVO, S.[1], DEBRUYNE, R.[2], SCHAEFER, H.[1,3], GORSKY, D.[4], IRELAND, S.[2], ROSEMAN, E.[2], [1]University of Toledo; [2]U.S. Geological Survey; [3]University of Michigan; [4]US Fish and Wildlife Service. **Distribution of Larval Coregonines in Southern Lake Erie**.

Cisco (Coregonus artedi) and lake whitefish (C. clupeaformis) historically supported a robust commercial fishery in Lake Erie. By the mid-20th century, the fishery declined due to overfishing, habitat degradation, and invasive species impacts. Increased interest in coregonine restoration identified the need for contemporary information on spawning and nursery habitat. Historic and known spawning and nursery habitats require the adults to move from cold deep waters to cooling shallow waters with hard substrate like rock, gravel, or firm sand. To address this, pelagic coregonine larvae were sampled in 2017 and 2019 at 38 sites along the southern US shore of the central and eastern basins of Lake Erie with some sites near known historic spawning reefs. Coregonines were detected in April and May at 26 of the 38 sites, with densities peaking in mid-April. Larval densities were highest near Sandusky, OH, close to the western basin where known widespread lake whitefish reproduction occurs. In addition, catches of yolksac larvae in the eastern basin indicates additional coregonine spawning is likely occurring. Our results provide a contemporary assessment of coregonine larval distribution in Lake Erie and insight about spawning and nursey habitat necessary to develop restoration and recovery strategies. A logical next step is identification of local spawning sites through detection of eggs, planned for fall 2021.

PRZYBYLA-KELLY, K.[1], SHIVELY, D.[2], SPOLJARIC, A.[2], KOSTELNIK, E.[1], EVANS, M. A.[1], [1]United States Geological Survey; [2]Michigan State University. **Four lakes, four years: How does Cladophora biomass in Lake Erie weigh in against other Great Lakes?**

Excessive growth of Cladophora dominated benthic algal communities can cause ecological, economic, and societal harm, leading to calls for Cladophora management through nutrient reductions under the 2012 Great Lakes Water Quality Agreement. However, the degree to which nutrient reductions can affect Cladophora growth in the current, dreissenid impacted, benthic ecosystem remains a question. The U.S. Geological Survey (USGS) has conducted sentinel site assessments on the south shore of Lake Erie's eastern basin, as well as in Lakes Michigan, Huron, and Ontario, since 2018. Within and among year patterns in Cladophora and dreissenid biomass, tissue nutrient content, as well as environmental drivers will be described for Lake Erie sites and placed in context of results from other Great Lakes. Preliminary findings support a stronger role of light and water clarity than of water column nutrients in determining Cladophora community biomass at the basin scale.

PU, G., Cleveland Water Alliance. **Lake Erie Water Innovations from the perspective of the Water Innovation Postdoc**.

Lake Erie water innovations is critical for monitoring and protecting our precious water resources in the Great Lakes region. Jeff Pu, a postdoc supported jointly through Cleveland Water Alliance, NOAA CIGLR, and LimnoTech will share his perspectives and his work on Lake Erie water innovations. Jeff will present his work on water sensor deployments and water data analytics around various parts of Lake Erie region. He will present his ongoing work related to various innovations in water monitoring that includes buoy networks, affordable sensor kits, and advanced IoT networks. Jeff will share his knowledge and lessons learned from participating in various Lake Erie water monitor projects. Ultimately, through his presentation, Jeff hopes to gain diverse perspectives on his work and explore new collaboration opportunities for contributing to Lake Erie water innovations.

PU, G., Cleveland Water Alliance. **Monitoring Lake Erie water resources using affordable IoT sensors: examples and quickstart guides**.

Traditional water monitoring equipment utilized near the Lake Erie shoreline has been expansive and thus limiting the monitoring spatial coverage. However, critical Lake Erie water phenomena such as shoreline flooding/erosion, meteotsunamis, and upwelling have been proven to be spatially variable. With the rapid development of microcomputers and Internet of Things (IoT), environmental monitoring costs are becoming increasingly affordable yet robust, which provides the perfect opportunity to increase Lake Erie water monitoring coverage with affordable means. However, with hundreds to thousands of affordable sensors and vendors currently available on the market, it is hard for one to start without any prior knowledge or experience. This workshop will review some basics of affordable and IoT sensors and showcase existing examples in the Lake Erie region to help educate and promote deployment of these sensors. In addition, this workshop helps participants get started by providing step-by-step instructions on how to purchase, configure and view real-time data using a recently developed affordable sensor kit. This workshop is suitable for those interested in conducting environmental monitoring at a fraction of the cost. Ideal audiences would be managers, researchers, students, stakeholders, or any concerned public. An additional perk for attending this workshop is gaining access to an online workshop series on how to get started with affordable environmental sensors.

R

RAHMAN, A.[1], SHAMIM, A.[2], RAFIQ I.[1], [1]Ohio State University; [2]Metropolitan State University. **Soil accumulation and edge-of-field loss of phosphorus to surface water under diverse agricultural management practices in Ohio**.

Phosphorus (P) is one of the most important but reactive macronutrients essential for plant growth. While the role played by soluble reactive phosphorus (SRP) in surface water eutrophication, the susceptibility of soils under variable management practices to edge-of-field (adsorption vs. desorption) SRP loss requires more practical assessment. The objective of our study was to determine P loss threshold values using the oxalate P extraction and predict edge-of-field P loss from soils under conventional tillage (CT), no-till, organic agriculture, and chicken- and dairy manured management practices. Using all the data, the threshold PSR (P saturation ratio) was determined 1.2 and used to calculate the soil P saturation capacity (SPSC) to evaluate the risk of edge-of field P loss. The P loss threshold (STP) was determined 94 mg/kg oxalate-P (equivalent to 22 mg/kg Mehlich-3 P), using SRP and PSR data. In addition, the degree of P saturation (DPSox) critical values were determined 24% using SRP to compare edge-of-field P loss. Results suggested that both SPSC and DPSox indices showed similar trends and could be used alternatively as an early indicator to predict and estimate edge-of-field SRP loss from soils under diverse management systems and contribute to reduce the excess P load in Great Lake systems.

REAVIE, E.[1], PERLOV, D.[2], ELLIS, D.[2], QUINLAN, R.[2], CAI, M.[1], TWISS, M[3], CARRICK, H.[4], DAVIS, T.[5], JOHENGEN, T.[6], GOSSIAUX, D.[5], SMITH, D.[7], PALLADINO, D.[6], BURTNER, A.[6], SGRO, G.[8], [1]University of Minnesota Duluth; [2]York University; [3]Clarkson University; [4]Central Michigan University; [5]Great Lakes Environmental Research Laboratory; [6]Cooperative Institute for Limnology & Ecosystem Research; [7]Colorado School of Public Health; [8]John Carroll University (retired). **Long-term data clarify the nature of Lake Erie's hypoxia**.

Re-eutrophication, harmful algal blooms and hypoxia in Lake Erie have resulted in a renewed call for remedial measures such as reductions of nutrient loads. Successful remediation requires historical context of the lake's condition so that management practices are applied appropriately. Here I describe two types of long-term, retrospective data collections that have informed on hypoxic condition. Chironomidae (Diptera) remains in a dated sediment core from the central basin were used to assess the long-term effects of multiple anthropogenic stressors on hypolimnetic dissolved oxygen. Subfossil remains indicated that hypoxia (and associated mesotrophic to eutrophic conditions) has existed since at least 1850. A transition in chironomid communities further towards anoxic-type taxa between 1930-1950 suggests that the severity and duration of hypolimnetic anoxia has increased in recent decades. Further, comparison of spring and summer phytoplankton abundance in Lake Erie based on monitoring data show that spring phytoplankton biovolume was ~6-fold greater than summer biovolume and that spring algae were mainly diatoms, that are likely supported by silica loading from Lake Huron. Winter-spring diatoms, not summer cyanophytes, are probably contributing the majority of the biological carbon load to the hypolimnion of the central basin of Lake Erie. Though important carbon sources for the central basin profundal zone still need characterization, remedial measures aimed at reducing hypoxia in Lake Erie should consider these early-year blooms as an important source of organic material.

ROBERTSON, D., SAAD, D., U.S. Geological Survey. **Use of SPARROW model results and limited tributary monitoring to estimate loading from the entire Great Lakes Basin**.

It is important to routinely estimate the total nutrient loading to the Great Lakes from its watershed to evaluate the success of efforts being made to reduce nutrient loading and determine whether water-quality improvements can be expected in the lakes. However, monitoring of the tributaries to the Great Lakes, like most aquatic systems, consists of monitoring at a limited number of sites that is only periodically evaluated. In this presentation, a technique is described that was developed to extrapolate the monitored loads at selected tributaries to the total loading to the Great Lakes using results of published SPARROW models (SPARROW ratios – ratios of nonpoint loads between monitoring tributaries and nearby unmonitored areas within the Basin), annual point-source inputs throughout the basin, and annual (or shorter term) monitored loads from tributaries in consistent ongoing monitoring programs (such as the Great Lakes Restoration Initiative Tributary Monitoring Network). This SPARROW-ratio approach incorporates the spatial variations in point and non-point nutrient sources, watershed characteristics (such as land use, soil types, etc.), and hydrology when estimating loads from the unmonitored areas. Nutrient loadings from ~25 monitored tributaries throughout the Basin are being computed by the U.S. Geological Survey using surrogate regressions and Weighted Regressions on Time Discharge and Season (WRTDS) techniques to better describe short-term loads and improve their accuracy from those previously estimated with Beales-Ratio techniques. To demonstrate how loading estimates from this SPARROW-ratio approach compare with estimates of the previous approach used to estimate total watershed loading (extrapolation based on unit-area yields from nearby monitored tributaries), total loadings from the entire U.S. part of the Lake Erie Basin are compared for water years 2012 and 2013 (the last years with phosphorus loads estimated for the entire Lake Erie Basin).

ROSEMAN, E.[1], DEBRUYNE, R.[1], HILLING, C.[1], BOASE, J.[2], CHIOTTI, J.[2], FISCHER, J.[2], DROUIN, R.[3], WILLS, T.[4], [1]U.S. Geological Survey Great Lakes Science Center; [2]U.S. Fish and Wildlife Service; [3]Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry; [4]Michigan Department of Natural Resources. **Science and Monitoring Guide Recovery of Fisheries Habitat and Populations in the St. Clair-Detroit Rivers System**.

The St. Clair-Detroit River System (SCDRS) contains the St. Clair River, Lake St. Clair, and the Detroit River connecting Lake Huron to Lake Erie in the densely populated Detroit/Windsor metropolitan areas. Losses of fish habitat and other perturbations resulted in the designation of portions of the SCDRS as Great Lakes Areas of Concern with loss of fish habitat and degradation of fish populations identified as Beneficial Use Impairments. Efforts to remediate and delist this BUI have focused on restoring habitat for native fishes and overall aquatic ecosystem health. To date, investigations have focused on site-specific effectiveness of restored habitats with only a few long-term aquatic community assessments. While these investigations have done well to provide site-specific validation of the success of individual restoration projects, they lack a credible long-term measure of fish population trajectory in response to habitat improvements. As part of a collaborative initiative, we implemented a scientific strategy for coordinated research and monitoring that incorporates a long-term vision for ecosystem recovery to measure the response of the system to restoration. Our approach capitalizes on the collective impact concept to measure progress and make efficient use of resources available for restoration.

ROWE, M., NOAA Great Lakes Environmental Research Laboratory. **Simulation of inter-annual variation in Lake Erie hypoxia timing and extent with a physical dissolved oxygen model**.

We developed a physical dissolved oxygen model that generated a daily nowcast and forecast of three-dimensional fields of dissolved oxygen (DO) in Lake Erie. 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. The model applies a specified rate of sediment oxygen demand that is temperature-dependent, but otherwise constant across years. We assessed the ability of this model to represent inter-annual variation in hypoxia for years from 2010-2021. This study provided insights on physical versus ecological drivers of hypoxia, and our ability to determine whether sediment oxygen demand varies across years.

RYAN, T., JOSSE, P., PAGE, E., Agriculture and Agri-Food Canada. **The Living Lab-Ontario Project**.

The Living Laboratory Initiative was launched by Agriculture and Agri-Food Canada (AAFC) to provide an integrated approach to agricultural innovation, bringing farmers, scientists, and other partners together to co-develop, test, and monitor agricultural best management practices (BMPs) and new technologies in a real-world context. The Initiative is a network of Living Labs across Canada where farmers, researchers, agricultural organizations and environmental organizations can work together on real working farms to develop innovative practices and approaches to address local agro-ecosystem challenges. Through regional consultations Lake Erie Basin was identified as the are of focus for Living Lab – Ontario. The research conducted in Ontario focuses on reducing the soil and nutrient runoff from agricultural land into Lake Erie, conserving soil health, and increasing biodiversity on agricultural lands in Ontario. The project brings together 4 agricultural organizations, interested in achieving continuous cover and reduced tillage and 3 organizations concerned with watershed management as well as scientists from AAFC and Environment and Climate Change Canada (ECCC). Collectively the partners are working together to meet the objectives of the Living Lab project.
There are 6 farmers participating each with their own systems and innovations being studied. The participating farmers represent a diversity of farm sizes and operation types. Through the Living Lab project, the researchers and farmers work together to develop and test innovations in the field. The aim is to develop practical technologies and practices that make sense for Canadian farmers to help them adjust to climate change, reduce water contamination, improve soil and water conservation, and maximize habitat capacity and biodiversity on agricultural landscapes. In Ontario the objective of the field trials is to measure crop production and environmental impacts of various farm management strategies to achieve continuous cover crops and/or minimum tillage. Socio-economic data is being collected at the farm and watershed scale to identify the costs, benefits and barriers to implementing practices that improve soil health and water quality. Watershed monitoring and modelling studies are also being conducted to measure the impact of best management practices on nutrient cycling and aquatic health. Communicating and sharing results is also part of the project.

S

SAKAS, A.[1], THOMSON, G.[2], [1]The Nature Conservancy; [2]Baird. **Landscape Scale Restoration to Address Lake Erie Harmful Algae Blooms**.

The increasing recognition, commitment, and investment around solving Lake Erie's water quality issues have generated momentum toward a more sustainable trajectory that will benefit nature and human wellbeing. Over 90% of Ohio's wetlands have been lost, including the 4,800 square mile region historically known as the Great Black Swamp. With these losses went our wetlands' ecosystem services, including their ability to filter pollutants before they reach our waterways and the lake. Therefore, The Nature Conservancy (TNC) is focused on strategically

restoring natural infrastructure and its functionality to maximize wetland benefits. The sustainability of investments being made is vital to improving Lake Erie water quality, and hinges on the effectiveness of the many ongoing collaborative projects. One such example is the Sandusky Bay Restoration Initiative, launched by the Ohio Department of Natural Resources (ODNR) Office of Coastal Management, with an aim of implementing landscape scale restoration to enhance nutrient assimilation benefits of restored and created wetlands. Over the past 18 months, TNC, in collaboration with ODNR and ongoing research activities, completed a series of design plans for projects based on an ecological functions design approach. Once implemented, the projects are expected to reduce sediment resuspension, enhance nutrient processing and assimilation, and provide habitat for fish and wildlife. Following an adaptive management approach, initial projects will help to further refine and optimize the designs to solve lacustrine harmful algae blooms and related water quality problems at a landscape scale.

SCAVIA, D.[1], WANG, Y.[1], OBENOUR, D.[2], [1]University of Michigan; [2]North Carolina State University. **Advancing Harmful Algal Bloom Forecasting in Western Lake Erie**.
Meeting the GLWQA phosphorus loading targets for harmful algal blooms (HAB) in western Lake Erie continues to be a challenge. The current target was guided by a suite of HAB models assembled in 2016. Models have evolved since then, and adaptive management frameworks suggest revisiting previous analyses. In this study, we reformulated a Bayesian HAB model considering internal phosphorus recycling and a longer-term dataset including three independent sets of HAB estimates. We tested the model through cross validation (CV) and simulated blind forecasts, quantified uncertainties, and applied it for hindcasts, forecasts, and scenarios. The revised model explains 77% of the 2002-2020 interannual variability, a 24% increase over our most recent model that does not include phosphorus recycling, with a CV R2 of 0.59. The new model's simulated blind forecasts explained 60% of HAB variability between 2014 and 2020, the years that actual forecasts were made. This suggests a significant improvement compared to the actual forecasts that explained just 32% of inter-annual variability. Because of internal phosphorus recycling, represented in the model with historical cumulative load, the model suggests it could take 9-11 years for a full HAB response once annual loading targets are reached. However, when the full response, including the cumulative load, is realized, the model predicts a substantial overshoot of the policy target. According to the model, relaxing the loading target to the 2008 load instead of a 40% reduction from 2008 could still reach the HAB goal of HABs comparable to extents in 2004 and 2012.

SELZER, M., Michigan Department of Environment, Great Lakes, and Energy. **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.

SELZER, M.[1], STAMMLER, K.[2], [1]Michigan Department of Environment, Great Lakes, and Energy; [2]St. Clair Detroit River System Intiative Canadian Co-chair, Essex Region Conservation Authority. **St. Clair-Detroit River System Initiative Update and Charting the Course for the Future**.

The St. Clair-Detroit River System (SCDRS) Initiative is a bi-national environmental initiative that brings together more than 30 organizations, including U.S. and Canadian natural resource-related agencies, Tribes/First Nations, units of local government, industry and university partners, non-profits, and interested citizens with a common vision: the restoration of portions of southern Lake Huron, the St. Clair River, Lake St. Clair, the Detroit River, and western Lake Erie to a thriving ecosystem with science-based management and broad social support that provides environmental services for the region and the Great Lakes basin. The SCDRS Initiative uses a "Collective Impact" approach and a Partnership Agreement to coordinate research and management efforts to achieve measurable progress toward the fulfillment of the Priority Objectives. The strength of the SCDRS Initiative lies in the collective contributions of its partners, who contribute to the Initiative by providing leadership and guidance, assisting with administration, planning and implementation of protection and restoration projects, and coordinating and conducting binational research. In 2013, the SCDRS Initiative established Priority Objectives to guide our work for the 10-yr Initiative (2013-2023).
This presentation will provide an overview of the Priority Objectives and progress towards achieving our 10-year goals. The presentation will also chart the course for what may be next for the SCDRS Initiative Partnership.

SENKO, J.[1], MONTY-BROMER,C., DAVIS. D., CHINTHALA, P., KINSMAN-COSTELLO, L., MORIN, T., [1]University of Akron. **Development of an electrochemical approach to monitor sediment biogeochemistry**.

We are developing an approach to use zero resistance ammetry (ZRA) measurements to detect biogeochemical processes at a variety of scales in sediments. These measurements exploit redox disequilibria among discrete zones of sediments to detect the distributions, extents, and kinetics of biogeochemical processes. ZRA can be used to measure electrical current that arises from conditions of microbially-induced redox disequilibrium. ZRA-based measurements represent a low-power approach to detecting and monitoring microbially-controlled biogeochemical processes at a variety of scales (sub-millimeter to decimeter). In the current work we sought to determine if microbiological Fe(III) reduction could be detected by ZRA measurements, and if this could be used to predict phosphate solubility. In incubations to mimic field-based ZRA measurements, we deployed graphite electrodes in opposing chambers of a split cell setup. When both chambers were incubated under oxic or anoxic conditions, no current was observed. However, when one chamber was incubated with poorly crystalline Fe(III) (hydr)oxide under oxic conditions and the other chamber was incubated with poorly crystalline Fe(III) (hydr)oxide under anoxic conditions, no Fe(III) reduction was observed in the oxic chamber. In the anoxic chamber Fe(II) accumulated due to microbiological Fe(III) reduction, and this activity was accompanied by electron transfer from the anoxic chamber to the oxic chamber. In corresponding batch incubation, release of Fe(III) (hydr)oxide-adsorbed phosphate accompanied the initial stages of Fe(III) reduction, but further biogenic Fe(II) accumulation led to precipitation of phosphate, likely as vivianite. These results indicate that graphite electrodes can be deployed in sediments, and the electrochemical signatures that arise due to microbiological activities can be detected at a variety of scales.

SERRAN, J., Detroit River Canadian Cleanup. **Tipping the scales of progress: Ongoing remediation on the Canadian Detroit River Area of Concern restores beneficial uses**.

In 1987, the Detroit River was named one of 43 Great Lakes Areas of Concern (AOC). An AOC is a location where environmental quality is degraded compared to other areas in the Great Lakes Basin resulting in the impairment of beneficial uses. Issues facing the Canadian side of the Detroit River include combined sewer overflows, urbanization, degradation of habitat, and toxic contaminants. These issues led to environmental degradation causing 13 of 14 beneficial uses to be impaired or requiring further assessment. To date, the cleanup plan for the Detroit River AOC has been implementing actions to remove contaminated sediments, improve sewage treatment, conduct monitoring and research, and create and restore habitat in the river and its watershed. These initiatives have contributed to 9 of the 13 beneficial uses that were previously impaired or required further assessment for the Canadian side of the Detroit River to be considered no longer impaired, with three of these nine beneficial uses having their status changed over the past year and a half. Here, the research, monitoring, and restoration efforts that went into changing the status of these three beneficial uses (Degradation of Benthos, Fish Tumours and Other Deformities, and Degradation of Phytoplankton and Zooplankton Populations) to not impaired will be highlighted. Additionally, actions underway or planned to address the remaining impaired beneficial uses (Restrictions on Fish and Wildlife Consumption, Degradation of Fish and Wildlife Populations, Birds or Animal Deformities or Reproductive Problems, and Loss of Fish and Wildlife Habitat) on the Canadian side of the Detroit River will be showcased.

SIRVIENTE, A., PAIGE, K., PEARSON, B., KEARNS, T., Great Lakes Observing System.
Development of a Lake Erie Harmful Algal Bloom Early Warning System.

Harmful Algal Blooms (HABs) that occur during the summer in Lake Erie are a persistent annual problem that has threatened human health, affected the quality of life, and significantly degraded the lake's ecosystem. Roughly one-third of the total population of the Great Lakes basin is in the Lake Erie watershed and the lake is the primary source of drinking water for approximately eleven million people. Monitoring, research, and analysis increased in Lake Erie as a response to the 2014 drinking water crisis in Toledo, OH. However, the establishment of sustained observing assets, data integration pipelines, and optimized information products are in the early stages of maturity and require additional coordination, resources, and planning to ensure a viable transition to operational status. This presentation will showcase the work conducted by the Great Lakes Observing System (GLOS) from 2017 through 2020, along with NOAA Great Lakes Environmental Research Laboratory (GLERL), the Cleveland Water Alliance (CWA), LimnoTech (LTI), and NOAA Center for Coastal Environmental Health and Biomolecular Research (CCEHBR), to understand the network of local monitoring and data sharing activities underway in western Lake Erie, and to enhance both the in-situ monitoring capabilities and the data management and communications support structure.

SMITH, M.[1], WILKERSON, R.[1], GLOWCZESKI, J.[1], CUTRIGHT, T.[2], [1]City of Akron Water Supply Bureau; [2]University of Akron.
Novel Use of Water Treatment Residuals for Phosphate Removal in the Upper Cuyahoga River Watershed.

Drinking water system (DWS) managers need to mitigate phosphorus loading to source waters to prevent eutrophication and toxic algae blooms. Prior research has shown that aluminum-based water treatment residuals (WTR) can effectively sorb phosphate in surface waters. The City of Akron Water Supply Bureau designed and evaluated a novel use of WTR to retain phosphate that, unlike other common approaches, avoids permanent application of WTR to drinking water reservoirs. Removable, WTR-filled cartridges were installed into a series of 8 "gates" located in a small tributary to Lake Rockwell, a drinking water reservoir in the Upper Cuyahoga River watershed. May through October 2021, bi-weekly measurements of soluble reactive phosphate (SRP)

concentrations were taken upstream and downstream of each gate, and of the entire series, to assess the effectiveness of this approach. Preliminary results showed no significant difference between upstream and downstream SRP concentrations at neither gate-scale, nor whole-practice-scale. However, SRP concentrations were generally lower when and where gate submersion was greater, indicating this approach may be better suited to systems where water will have more contact with WTR on a temporal and spatial scale. Future project work will test a similar approach in an agricultural ditch or swale.

SPARKS-JACKSON, B.[1], MILLER, J.[1], HINTZ, W.[2], SHANE, K.[2], COCCA, P.[3], BUCKLER, K.[3], HINTERBERGER, B.[3], ANDOL, R.[3], BLAIR, C.[4], [1]U.S. Geological Survey; [2]University of Toledo; [3]U.S. Army Corps of Engineers; [4]Ohio Environmental Protection Agency. **Science-based decisions guide the development of ecological restoration projects in the Maumee River**.

The Maumee Area of Concern (AOC) needs viable and effective aquatic restoration projects to address three Beneficial Use Impairments (BUIs) in the mainstem of the Maumee River: Degradation of fish populations, degradation of benthos, and the loss of fish habitat. Restoration projects across the Maumee AOC were developed through a cooperative approach based on data supporting BUI status, project location, project feasibility, and stakeholder support. However, identifying and developing projects in the mainstem of the Maumee River presented additional challenges to this process. Challenges included a need for additional habitat and biological data, identification of restoration elements capable of withstanding strong water and ice flows and with minimal long-term maintenance requirements, complicated logistics of working in a large river setting, and a desire to minimize the effects of projects' footprint and construction on recreation and navigation. We used a BUI-focused framework to address these challenges and to guide a multi-agency feasibility study in 2021. The Great Lakes Restoration Initiative funded feasibility study was led by the U.S. Geological Survey and U.S. Army Corps of Engineers, in partnership with the University of Toledo and Hull & Associates, LLC, and at the direction of the Maumee AOC Advisory Committee and Ohio Environmental Protection Agency. The feasibility study team developed preliminary designs for restoration projects at three locations in the Maumee River. In this presentation, we provide specific examples of how our collaborative approach with BUI-based decision making guided the development of the preliminary designs.

STAMMLER, K., Essex Region Conservation Authority. **The Great Lakes HABs Collaborative-linking science and management to reduce blooms**.

Since 2015, the Great Lakes Commission has supported the Great Lakes HABs Collaborative, creating a forum for academia and government to connect and discuss shared goals and the scientific understanding needed to achieve those goals. GLC staff will provide an overview of the Collaborative, its structure, and recent products which include a fact sheet on key knowledge gaps and a new online dashboard allowing researchers to identify their projects as a tool supporting collaboration among researchers, water managers, and funders.

STOLL, J., COSTELLO, D., Kent State University. **Does zinc limit organic phosphorus remineralization in stream biofilms?**

Phytoplankton growth and toxin production in lakes are driven by macronutrient availability, therefore it is critical to understand processes that influence macronutrient loading from tributaries to protect downstream systems. When the biologically preferred inorganic forms of macronutrients (i.e., NH4 and PO4) are at low concentrations in rivers, stream biofilms may increasingly rely on organic pools of macronutrients to grow and maintain metabolic function. To access organic phosphorus, alkaline phosphatase is used to cleave PO4 from P-containing organic molecules. This

enzyme requires zinc (Zn) as a micronutrient cofactor, and thus Zn limitation may modify organic P remineralization. We conducted a series of in situ nutrient enrichment experiments using nutrient diffusing substrate to elevate macronutrients and Zn at the patch scale and measured responses on biofilm biomass and process rates. Experiments were completed in Breakneck Creek, which is a tributary of the Cuyahoga River (Lake Erie watershed) that delivers high loads of organic and inorganic nutrients, and the west branch of the Mahoning River. Biofilms enriched with NH4 had 164-324% higher alkaline phosphatase activity (APA) than controls, while biofilms enriched with PO4 had 53-72% lower APA than controls (53-72%). The ability of biofilms to remineralize organic nutrients can be limited by enzyme metal cofactor availability, though we did not see evidence of Zn limitation of APA or growth at our sites.

STOW, C.[1], GODWIN, C.[2], ALSIP, P.[2], KRAUS, R.[3], MASON, L.[1], ROWE, M.[1], CONSTANT, C.[1], JOHENGEN, T.[2], [1]NOAA Great Lakes Environmental Research Laboratory; [2]University of Michigan; [3]U.S.Geological Survey. **Seasonal stratification and hypolimnetic hypoxia in and around Lake Erie's central basin**.

Seasonal hypolimnetic hypoxia has been a regular occurrence in Lake Erie's central basin since at least the late 1950s, although past monitoring has focused on >20-m deep areas. To examine the extent and seasonal progression of hypoxia at mid- to deep locations (12-24 m) we deployed eight moorings from 2017-2019, each outfitted with temperature and dissolved oxygen sensors at several depths throughout the water column. Deployment was typically in late May, with retrieval in late September; data were logged at ten-minute intervals. Our results showed that hypoxia first developed in ~12 m areas in the western central basin in July and progressed east along the Ohio coast before appearing in the deepest area of the central basin in late August-early September. Once formed, hypoxia at locations along the Ohio coast was intermittent, likely due to upwelling or other water displacement. In the ~20m areas, once formed, hypoxia persisted into late September and often included an extended period of anoxia. Our observations indicate that hypoxia is likely more spatially extensive and temporally variable than is generally recognized and suggest that regular monitoring should be expanded to accurately assess progress toward meeting hypoxia goals under the Great Lakes Water Quality Agreement.

SUMMERS, M., MOU, X., Kent State University. **Removal of Cyanotoxins from Drinking Water through Biological Filtration**.

Cyanobacterial harmful algal blooms (CyanoHABs) occur frequently in eutrophic freshwater systems, including Lake Erie. Several cyanotoxins that are of many health concerns, such as microcystin, saxitoxin and anatoxin-A are commonly produced during CyanoHABs and have been detected on multiple occasions in the source and even finish waters of several water plants in the Lake Erie watershed. Previous research has shown that certain species of bacteria are capable of degrading these cyanotoxins. My projects search to utilize this microbial feature in application of water treatment to remove the cyanotoxins from drinking water and investigate the mechanism of biological filtration in local drinking water facilities in cyanotoxin removal. It also aims to determine the types of bacteria that are colonizing the filtration system and are responsible for the removal/degradation of the toxins from the influent water. Lab scale sand filters were constructed to represent the filtration system present at the Akron Water Treatment Facility. The filters were primed with source water from Lake Rockwell (Kent, Ohio) for 2 months to allow for a biofilm to grow within the layers of the filter. The system was then fed with cyanotoxins to simulate a bloom and effluent samples were collected. Toxin concentrations were measured by both ELISA and high-performance liquid chromatography (HPLC). The bacterial community that colonized the column will be samples and sent for DNA sequencing to determine the composition. This will help us

determine the bacteria that have the capability to remove/degrade the cyanotoxins. This process was repeated over several weeks and the data is not yet analyzed for all weeks. The initial results show that anatoxin-a had the highest removal in columns with anthracite. The results also showed that the columns without any GAC had lower removal percentages than the columns with GAC.

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TELEP, J., Northeast Ohio Regional Sewer District. **The Burning River 53 Years Later: Historical Improvements in the Cuyahoga River Area of Concern**.
The Northeast Ohio Regional Sewer District (NEORSD) operates three wastewater treatment centers and manages a regional stormwater systems within the Cuyahoga River Area of Concern (AOC). Established by court order shortly following the last of the fires on the Cuyahoga River, the NEORSD has worked to address beneficial use impairments (BUIs) through improvement of wastewater treatment processes, establishment of an industrial pretreatment program, elimination of illicit discharges, and enhancement of storm and sanitary sewer collection systems. Here we will present a history of the improvements in the Cuyahoga River AOC following the establishment of the NEORSD. The discussion will include summaries of over 30 years of water quality, riverine habitat, and biological survey data which demonstrate improvements following execution of key point source elimination projects. We will provide an update on the status of four of the remaining BUIs and the progress being made for future delisting.

TOWNE, K., WRIGHT, G., US Fish and Wildlife Service. **Targeted Early Detection for Aquatic Invasive Species in the St. Clair-Detroit River System**.
The most effective method to impede the establishment of newly introduced aquatic invasive species (AIS) is an extensive early detection and monitoring program to identify their presence as early as possible. This allows for control efforts to be implemented while the species range is still limited, maximizing their probability of success. The US Fish and Wildlife Service Early Detection and Monitoring Program has completed annual sampling for novel invasive species in Lake Erie since its inception in 2013. With the maturation of the program has come expansion into new gears, new locations, and new methodologies and analyses. Namely, sampling methods have shifted from standardized to targeted with the goal of maximizing the detection rate of rare species, an adequate surrogate for a newly introduced non-native species. With these modifications, the program has evolved from completing 23 units of effort and detecting 39 species in the SCDRS in 2013 to completing 163 units of effort and detecting 65 species in 2021. The objective of this presentation is to provide an overview of the evolution of the USFWS Early Detection and Monitoring Program in the St. Clair-Detroit River System. Results from targeted sampling efforts in 2019-21 will be compared to those from more standardized assessments conducted from 2013-18.

TUCKER, T.[1], TANK, S.[2], CANNIFF, P.[2], GRUNINGER, T.[2], DUMOULIN, C.[3], BARGERON, C.[3], JENSEN, E.[2], MOORE, C.[1,3], KOWALSKI, K.[1], [1]U.S. Geological Survey; [2]Great Lakes Commission; [3]University of Georgia. **The Great Lakes Phragmites Collaborative: Supporting science and management of an invasive grass in the St. Clair-Detroit River System**.
The perennial non-native grass Phragmites australis has invaded much of the Great Lakes region, resulting in degraded ecosystems and increased resource management costs. In the St. Clair-Detroit River System (SCDRS), 2017 satellite mapping found that as much of 7.5% of the surrounding land cover may be occupied by Phragmites. Although a variety of techniques can be

used to manage Phragmites, managers face uncertainty surrounding effectiveness and cost-efficiency of treatments. In addition, while many entities are managing Phragmites, communication and coordination remains challenging. To address these regional issues, the USGS, Great Lakes Commission, and other regional partners formed the Great Lakes Phragmites Collaborative (GLPC) in 2011. The GLPC created and maintains a website (http://greatlakesphragmites.net/) as a central resource hub, hosts research- and management-focused webinar series, creates newsletters and blog posts, maintains a 700+ member listserv, and supports research and advisory teams. In 2017, the GLPC initiated the Phragmites Adaptive Management Framework (PAMF), a participatory science program and decision support tool designed to find the best strategies for managing invasive Phragmites in the Great Lakes region. Each year, participants submit monitoring and management data to PAMF, and in return receive site-specific, model-driven management guidance. Over time, the PAMF model learns based on the data provided, with an end goal of determining best management practices for Phragmites. Over 250 management units have been enrolled in PAMF, representing governmental agencies, NGOs, non-profits, and private citizens. More than 20 PAMF management units are from Areas of Concern within or connected to the SCDRS, and PAMF is seeking new participants from this area and throughout the basin. In this presentation, we provide an update on the GLPC's program status and the PAMF model learning process relevant to researchers and managers in the SCDRS and across Lake Erie.

TURNER, B.[1], MERANTI, L.[2], [1]Cleveland Metroparks; [2]Cuyahoga Soil and Water Conservation District. **Showcasing Volunteer Involvement in Stream Restoration**.

Bonnie Park is a restoration site along the East Branch of the Rocky River – a tributary of Lake Erie - located in Cleveland Metroparks Mill Stream Run Reservation. A lowhead dam in the river prevented full warm water habitat attainment, making Bonnie Park a site for major impairment. In 2017, Cleveland Metroparks received Water Resource Restoration Sponsor Program funding from Ohio EPA and a local sponsorship by the City of Akron to restore the water quality and habitat at this site. In this session, you will learn how dam removal, stream restoration, and volunteer engagement contributed to the revitalization of Bonnie Park in 2020.

V

VALIPOUR, R.[1], DEPEW, D.[1], DALLIMORE, C.[2], HIPSEY, M.[3], ZHAO, J.[1], MCCUSKER, M.[1], DOVE, A.[1], RAO, Y.[1], [1]Environmental and Climate Change Canada; [2]Hydronumerics; [3]University of Western Australia. **High-resolution modeling to simulate mussels' nutrient recycling and Cladophora growth in Lake Erie**.

We develop two different high-resolution three-dimensional hydrodynamic and water quality models for Lake Erie: AEM3D with a structured mesh and Tuflow-AE2 with an unstructured mesh. These models can resolve predominant physical and biochemical nearshore and offshore processes to study nutrient dynamics, with a particular emphasis on the northern nearshore region of Lake Erie's eastern basin. The water quality modules of both models include coupled mussels and Cladophora Growth Model (CGM) to assess the role of nutrient re-cycling by mussels and predict Cladophora growth in eastern Lake Erie. The models are validated using extensive nearshore hydrodynamic and water quality observations such as temperature and velocity profiles, total and soluble phosphorous, Cladophora biomass and tissue phosphorus measurements collected between April and September of 2013. Both models are used to evaluate the response of nearshore phosphorus concentrations and Cladophora growth due to changes in external phosphorus loading

and the results are compared with a previously developed high-resolution three-dimensional ELCOM-CAEDYM model with an offline CGM module without mussels.

VERHAMME, E.[1], CUTRELL, G.[1], HOLST, E.[2], [1]LimnoTech; [2]Cleveland Water Alliance. **Smart Lake Erie Watershed Initiative - Coming in 2022**.

In 2022 the Cleveland Water Alliance along with LimnoTech will be rolling out a massive investment in real-time observing assets and data management tools to help bring Lake Erie closer to its goal of becoming the first smart lake. The Smart Lake Erie Watershed Initiative includes a multi-million investment in additional real-time sensors, buoys, roll-out of a region-wide LoRaWAN telemetry system, and cutting edge digital tools to view and manage data, alerts, and onboarding new sensors. The 2022 program also includes investments in private LTE networks, development of testbed sites for piloting new sensors, and a host of sensor deployments at Cleveland Metroparks, shorelines sites, beaches, and many other locations throughout the region.

VILLA, J.[1], KINSMAN-COSTELLO, l.[2], JOHNSON, N.[2] , SUTO, A.[2], KESLEY, D.[2], [1]University of Louisianna at Lafayette; [2]Kent State University. **Understanding the role of microtopography and nutrient runoff in P accumulation rates of a freshwater estuarine wetland in Lake Erie**.

Phosphorus (P) runoff is one of the main drivers of persistent harmful algal blooms (HABs) in Lake Erie. Wetlands are significant phosphorus sinks, offering a valuable ecosystem service in watersheds where non-point source runoff of this nutrient is challenging to manage. With a drastic reduction of coastal wetlands in Lake Erie, the quantification of P accumulation in remnants wetlands and its drivers is needed to inform wetland creation, restoration, or conservation projects and strategies to enhance accumulation. We studied the P accumulation rates in an estuarine wetland across a microtopographic gradient and levels of influence from the main channel. We also assessed the relationship between P accumulation rates and runoff of orthophosphate (PO43-), ammonium (NH4+), and nitrate (NO3-) during the past ~20 years. We found that P accumulation rates were larger at the deeper microtopographic level (0.84 ± 0.24 gP m-2 y-1) than in the intermediate (0.45 ± 0.13 gP m-2 y-1) and shallow (0.42 ± 0.12 gP m-2 y-1) levels and did not vary in response to the influence of the main channel. Accumulation rates showed significant relationships of orders 1, 2, and 3 for NH4+ NO3-and PO43-, respectively. Our results highlight the relevance of watershed-level management practices of P and nitrogen (N) runoff to control P accumulation in wetlands. Also, the relevance of microtopographic considerations such as maximizing deep pools in wetland-related projects to enhance P accumulation.

WATKINS, J.[1], RUDSTAM, L.[1], FIGARY, S.[1], CURRIE, W.[2], BOWEN, K.[2], [1]Cornell University; [2]Fisheries and Oceans Canada. **Seasonal succession of zooplankton in Lake Erie in 2019**.

Zooplankton communities in Lake Erie are the most diverse and productive of the Great Lakes, and represent an important food for planktivorous fish. Long-term monitoring indicates that summer zooplankton biomass has recently increased in the eastern and central basins, but it is not yet clear whether that increase is due to increased primary production or a reduction of fish predation. Seasonal net-based sampling during 2019 as part of the CSMI efforts provides a view of the lakewide seasonal succession of the zooplankton community in all three basins. From April to August zooplankton biomass steadily increased following warming temperature, and transitions from a cyclopoid to a cladoceran dominated community in the Central Basin. Non-native zooplankton, particularly the predatory cladoceran Bythotrephes peak in July-August. Spatial variation in the summer zooplankton community is compared relative to the distribution of hypoxia in the central and western basins.

WHITMORE-STOLAR, E., WATKINS, J., RUDSTAM, L, Cornell University. **Non-native zooplankton of Lake Erie: new data and updates.**.

An important aspect of zooplankton biological monitoring efforts in Lake Erie is the detection of nonnative species. Here we present data analyzed at Cornell University as part of the Cooperative Science Monitoring Initiative (CSMI) Lake Erie year 2019. In the past six years five nonnative zooplankton taxa have been detected in Lake Erie, four of which were crustaceans and one rotifer Brachionus leydigii (Cohn, 1862). Of the four crustacean taxa, three were cyclopoid copepods: Thermocyclops crassus (Fischer, 1853), Mesocyclops pehpeiensis (Hu, 1943), and Cyclops divergens (Lindberg, 1936) and one a cladoceran species Diaphanosoma fluviatile (Hansen, 1899). These new species were detected in the western basin of Lake Erie from 2014-2019. We review historical crustacean zooplankton introductions to Lake Erie and provide updated information on the spatial distribution and abundance of these nonnative zooplankton taxa. Western Lake Erie continues to be the primary source of new species detections in the Great Lakes.

WONG, B., Hyfi. **Real-time Flood Maps from On-site Sensors**.

Greater Cleveland is home to over one million residents across several hundred square miles and had experienced significant rainfalls throughout 2021. The City of Toledo also experienced heavy rains and issued several flood warnings. Recently, both Lake Erie communities partnered with Hyfi to pilot a new generation of wireless water level monitors and reporting services. The sensor network helps directly monitor key locations to evaluate their capacity to mitigate flooding and reduce flows throughout major storm events. Live sensor data combined with real-time flood maps and notifications help local crews anticipate and respond to potential flooding situations. Initial results have shown promise for enhancing municipal flood management, as well as for engaging local community members such as paddlers and volunteer groups.

X

XIA, Z.[1], DEPEW, D.[2], VALIPOUR, R.[2], MACISSAC, H.[1], WEIDMAN, R.[1],[1]University of Windsor; [2]Environment and Climate Change Canada. **In situ grazing rates on lake seston by invasive dreissenid mussels: a control volume experiment**.

Invasive dreissenid mussels impact many freshwater ecosystems in North America and Europe. However, existing assessments of their ecological impacts are mainly derived from laboratory-based tests. In this study, we investigated in situ grazing on lake seston by dreissenid mussels (mainly quagga mussel Dreissena rostriformis bugensis) using a "control volume" approach in the nearshore of eastern Lake Erie. Flow conditions were profiled by an acoustic Doppler current profiler, which was surrounded by three vertical sampling stations that were arranged 50 m apart in a triangular configuration to collect time-integrated water samples from five different depths. Five lake seston variables, including chlorophyll a, phaeopigment, particulate organic carbon and nitrogen, and particulate phosphorus, were considered in estimating grazing rates and stoichiometric ratios along with water flow across mussel beds. We observed suboptimal flow velocity in the overlying water while water temperature was optimal for grazing. Concentrations of lake seston were low and generally decreased from surface to lakebed, where only a modest depletion layer was observed. Depth-interval grazing rates varied substantially among trials, with the averages peaking at 0.25 or 0.5 meters above lake bottom (mab). Flow velocity, food concentration, and water depth demonstrated consistently positive relationships with grazing rates of lake seston, whereas stoichiometric ratios had both positive and negative effects. Net negative grazing on lake seston was observed in the upper water column beyond 1.5 mab, whereas net positive grazing occurred

between 0.5 mab and lake bottom. Horizontal changes in stoichiometric ratios of lake seston were strongly associated with grazing rates, which revealed a higher recycling rate of particulate phosphorus than nitrogen and carbon near lake bottom. Our study supports the nearshore phosphorus shunt hypothesis and demonstrates the efficacy of the control volume approach in estimating in situ grazing rates of lake seston by dreissenid mussels.

Y

YANG, T.[1], MAYER, C.[1], DEBRUYNE, R.[2], ROSEMAN, E.[2], DUFOUR, M.[2], [1]University of Toledo; [2]U.S. Geological Survey. **Diets of Age-0 Walleye Reflect Food Web Changes in Western Lake Erie**.

Walleye (Stizostedion vitreum) are an ecologically, economically, and recreationally important fish species in Lake Erie that fluctuates in recruitment each year. Young walleye recruiting into adulthood is dependent on their growth and survival, which is directly affected by their diet during the first year of life. In the last few decades, Lake Erie has experienced several unintentional introductions of aquatic invasive species (AIS) that have likely led to environmental and food web changes, potentially impacting age-0 walleye diet and growth. To determine how the diet of age-0 walleye has changed in western Lake Erie, we compared diet composition from 2019 (new) with 1994 (historic) during late spring, summer, and early fall. We found that during late spring (larval pelagic walleye), cyclopoids dominated diets in 2019, which differed from 1994 when calanoids dominated diets. From summer to early fall (juvenile demersal walleye), we found that large Cladoceran species and benthic invertebrates made up a large portion of diets in 2019, which differed from 1994 when fish prey made up almost all of the diets. Additionally, two of the most recent AIS, the spiny water flea (Bythotrephes longinamus) and round goby (Neogobius melanostomus), were found in 2019 diets, confirming that age-0 walleye are adapting to the changing food web by incorporating new prey items into their diets. Our results suggest that zooplankton and benthic invertebrates may have become important prey items for age-0 walleye in Lake Erie, especially in the later months. Switching to diets dominated by smaller non-fish prey could have implications for walleye growth during their first growing season and ultimately their recruitment into adulthood.

YOUNG, R.[1], KEMP, C.[2], MAPES, R.[3], [1]U.S. Fish and Wildlife Service; [2]Michigan Department of Natural Resources; [3]University of Toledo. **An update on Grass Carp monitoring and control in Lake Erie**.

Grass Carp (Ctenopharyngodon idella) is an invasive carp species native to East Asia, first introduced to the United States in 1963 for biological control of aquatic weeds. Intensive introduction and unintentional release have resulted in natural reproduction in tributaries to Lake Erie; however, self-sustaining populations are not established. Grass Carp can negatively affect aquatic habitats and food web dynamics by voraciously consuming aquatic vegetation, which affects water quality. Recent collections of Grass Carp eggs (e.g., Maumee and Sandusky rivers) and larvae (e.g., Maumee River) in Ohio waters facilitated swift intervention by fisheries managers to limit population growth and future spread. An adaptive management process for Grass Carp was initiated in 2016 to evaluate potential response actions and elucidate key uncertainties used to refine future control efforts, which resulted in the development of a multi-agency Lake Erie Grass Carp Adaptive Response Strategy to be implemented from 2019-2023. One aspect of this strategy has been the creation of Grass Carp 'strike teams', tasked with monitoring and suppressing Grass Carp

populations through routine assessments and targeted removal. The number of strike teams have increased from three boats in 2019 to eight boats in 2021, allowing for the continued monitoring of high-priority tributaries identified by the Lake Erie Committee, while also facilitating the exploration of new systems previously not sampled for Grass Carp.

YUAN, F.[1], MAYER, B.[2], GUO, L.[3], [1]Cleveland State University; [2]University of Calgary; [3]University of Wisconsin, Milwaukee. **Dynamics of carbon and sulfur in the nearshore waters of Lake Erie: A chemical and isotopic reconnaissance study**.

While phosphorus-induced eutrophication has been studied extensively, dynamics of other nutrients such as sulfur and carbon has not been sufficiently explored. Concentrations of chloride, sulfate, dissolved inorganic carbon (DIC), dissolved organic carbon, d18O and d2H of water, sulfur (d34S-SO4) and oxygen (d18O-SO4) isotopic ratios of dissolved sulfate, and stable (d13C) and radio (d14C) isotopic ratios of DIC were measured in waters from Lake Erie, including nearshores, offshores, tributaries, and the Detroit River. While the Detroit River was featured with the lowest concentrations of Cl and SO4 and the highest values of d13C and d34S-SO4, the tributaries were characterized by the highest values of Cl, SO4, and d-excess, and the lowest values of d13C, d14C, d34S-SO4, and d18O-SO4. The nearshore waters had higher values of Cl, SO4, and d-excess, and lower values of d34S-SO4 and d18O-SO4 than the offshores, signaling a strong tributary influence. Using a d-excess-based binary mixing model, the tributary water contribution was estimated to be, on average, 56.1%. We found that majority of the dissolved carbon entering the lake was processed and evaded into the atmosphere. Moreover, our results were consistent with existing published data in indicating that d34S-SO4 decreased by over 1.2‰ from the Detroit River to the offshore central basin, further attesting to the tributary influence. By contrast, there was a concomitant 2.1‰ increase of d18O-SO4. Collectively, these results suggest that the dynamics of carbon and sulfur were also modulated by a range of in-lake biogeochemical processes, including CO2 degassing, microbial sulfate reduction, and subsequent reoxidation.

Z

ZHANG, N., WEI, X., KANDIAH, R., ROBINSON, G., NEDUNURI, K., Central State University. **Impact of hydraulic fracturing induced landscaping change on regional surface water quality in eastern Ohio**.

This work investigates the impacts of unconventional exploration induced rapid landscaping change on regional surface water quality in eastern Ohio. Unconventional exploration (e.g., shale gas hydraulic fracturing) has rapidly arisen over the last decade in the eastern Ohio. The landscaping alteration associated with this development has resulted deforestation and increased developed land areas on regional scale and further affected the hydrological cycling and non-point pollution process, which suspected to cause surface water quality decline as consequences. In this study, the landscaping patterns were studied in eastern Ohio at county level between 2006 and 2011. Two counties (Harrison and Carroll Co.) with largest deforestation were selected for follow up water quality assessment. A total of ten surface water sampling sites were selected along surface streams on the boundary of the two counties. Drainage basins were delineated for each sampling site using USGS StreamStats online tool. Land use and land cover was investigated for delineated basins over the period from 2013 to 2019 to study landscaping pattern alteration at class level. It shows forest land areas have maintained steady percentage (with less than ±1% changes) in majority of the drainage basins since 2013; during the same period, developed land areas have increased by a range from 1.5% to 4.7%. Surface water sampling were carried out in two years in 2018 and 2019. A total

of twenty water samples were collected from two streams and one reservoir. Eleven water quality parameters, including pH, dissolved oxygen, total suspended solids, conductivity, nitrate, Ba, Sr, Ca, and etc., were analyzed on site and in lab. Principal Component Analysis (PCA) were performed to determine the regional primary water quality variances. The PCA results show elevated impacts on water quality in the upstream sampling sites close to the unconventional well drilling fields. Pearson Correlation analysis shows stronger positive correlations between developed land areas and concentrations of inorganic elements than that between agricultural land areas and water quality parameters. Additionally, the elevated inorganic element levels are associated with the decreased forest land areas.