Abstracts

Wednesday, October 31

Session A1: Large Data Sets and Long-Term Monitoring

10:30 am – 12:00 pm | West Meeting Rooms 260–261

Taxonomic Data Quality of Benthic Macroinvertebrate Samples Used for the 2017 National Lakes Assessment

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The US Environmental Protection Agency has been executing consistent and technically defensible surveys of the Nation's water resources since 2004. The series of National Aquatic Resources Surveys (NARS) uses physical, chemical, and biological data to assess the condition of wadeable streams, large rivers, lakes and reservoirs, wetlands, and coastal waters. The 2017 National Lakes Assessment (NLA2017) took approximately 1,100 benthic macroinvertebrate samples from 1,000 lakes across the country. Samples have been laboratory-sorted to 500 organisms, and identified to standard hierarchical target levels, primarily genus. Quality control (QC) analyses on the data are being used to quantify identification error rates, isolate problematic taxa, and develop targeted corrective actions. The analyses are a direct sample by sample comparison of taxonomic identification results by independent laboratories and taxonomists, quantification of error rates (disagreements), and comparison to programmatic measurement quality objectives (MQO). To date, these analyses have been completed for 69 of the randomly-selected 10% of the total sample lot (n = 110), and numbers of taxa observed within samples range from 8–89. Although, the largest error rates have to do with inconsistently attaining target level, straight disagreements are dominant for Hydrobiidae, several genera of Chironomidae (for example *Hydrobaenus*, *Stempellinella*, *Dicrotendipes*, and *Cladotanytarsus*), *Gammarus*, *Nais*, among others. In spite of this, the running average taxonomic error rate (percent taxonomic disagreement [PTD]) is 8.8%, substantially better than the programmatic standard MQO of 15%. Seven samples exceeding have PTD ranging from 16.2–23.9. Compiled results from the project will serve as an objective, quantified statement of taxonomic data quality.

Structural Changes to Lake Ecosystems Resulting from Long-Term Browning

★ Rachel M. Pilla[1], Craig E. Williamson[1], Lesley B. Knoll[2], Jennifer A. Brentrup[3], Taylor H. Leach[4], Thomas J. Fisher[5], John D. Lenters[6], Elizabeth M. Mette[1], Robert E. Moeller[1], Erin P. Overholt[1], Robyn L. Smyth[7], and Jing Zhang[5]
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During the past several decades, many lakes have experienced changing water clarity, a fundamental structurer of lake ecosystems, resulting from a variety of external stressors. Even the most well-managed and protected lakes are susceptible to changes in atmospheric conditions that percolate to the lake via the watershed, including climate change and acid deposition. In northeastern Pennsylvania, two pristine lakes have shown marked decreases in water clarity since the 1980s due to continually-increasing carbon concentrations in the lake caused by increases in rain and storm events plus reduced atmospheric acid deposition. These two lakes have experienced concurrent changes in water temperature, water column stability, and deep-water oxygen availability. Decreases in water clarity have led to warmer surface water temperatures, and, due to the limited penetration of light and heat deeper in the lake, the bottom waters have significantly cooled at the same time. Combined, these changes have led to strong increases in summer thermal stability of the lake, which has reduced vertical mixing. One of the primary ecosystem consequences of this is oxygen depletion in the deeper waters. The deeper waters of these lakes no longer receive enough light for net photosynthesis to occur. Additionally, reduced vertical mixing limits the ability of oxygen to be replenished from shallower surface waters. These physical changes likely play a key role in the variety of other changes that have been observed in these lakes, including alteration of food webs and human-derived services.

Long-Term Trend Methodologies for Productivity Parameters Relating to Algal Blooms in Alberta Lakes

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Concern is increasing over the changes in productivity and severity of algal blooms in Alberta lakes. Long-term monitoring by the Alberta Lake Management Society (ALMS) and Alberta Environment has been active for decades. ALMS' LakeWatch program uses citizen scientists paired with trained technicians to collect a suite of water quality parameters on lakes across Alberta. However, a comprehensive trend analysis of these lakes has not been completed since 2008. In 2018, the Alberta Lake Management Society began running trend analysis on lakes with 10 or more years of data for the parameters chlorophyll *a*, total phosphorus (TP), total dissolved solids (TDS) and Secchi depth. While trends in Alberta Lakes have been assessed on various occasions, there is no standardized method for determining which test is appropriate for the data. This report will summarize methods of trend analysis using results from Pigeon Lake as a case study and propose a methodological way of choosing a trend analysis. Differences in temporal sampling and sampling effort across years can greatly skew trend results. Changes in sampling methods or timing may cause shifts in data that could be incorrectly interpreted as trends. It is therefore important to address this variation to ensure consistent methods and sampling effort over time. By displaying important long-term trends, stewards are able to take ownership of the data they are collecting and understand the changes happening in their lakes.

Cyanobacterial Blooms Modify Food Web Structure and Interactions in Western Lake Erie

Ruth Briland, Manjunath Manubolu, Josh Stone, Jiyoung Lee, and Stuart Ludsin
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With cultural eutrophication and climate change causing an increase in cyanobacterial blooms worldwide, the need to understand the consequences of these blooms on aquatic ecosystems is paramount. Key questions remain unanswered with respect to how cyanobacteria blooms affect the structure of aquatic food webs, the foraging abilities of higher consumers, and the potential for cyanotoxins (*e.g.*, microcystins, MCs) to accumulate in fish. Toward addressing these uncertainties, we sampled physicochemical attributes, water (for MCs), phytoplankton, zooplankton, and epipelagic and benthic age-0 fish at 75 sites (40 site for fish) of varying cyanobacteria concentration (0.1 to 44 µg/L) in western Lake Erie during the cyanobacterial bloom season, 2013–2014. Sites with high cyanobacteria biomass were characterized by *Microcystis* spp. (84–100% of biomass), detectible levels of MCs (maximum = 10.8 µg/L), and low water transparency (minimum = 0.25 m). Counter to our expectations, we found strong positive relationships between cyanobacteria concentration of edible phytoplankton, cryptophytes, and the biomass of several herbivorous zooplankton taxa (*e.g.*, *Daphnia retrocurva*, *Diaphanosoma* spp., *B.* (*Eubosmina*) *coregoni*, and calanoid copepods). Our expectations regarding fish were partly supported (*e.g.*, diet selectivity varied across a cyanobacteria gradient) and partly not (*e.g.*, consumption of zooplankton did not differ between bloom and non-bloom sites). Our findings show that cyanobacterial blooms can strongly affect the distribution, composition, and interactions of zooplankton and fish, sometimes in surprising ways, highlighting the need to further explore their impact on aquatic food webs.

Session A2: Combating Invasive Species

10:30 am – 12:00 pm | West Meeting Room 262

Quagga Mussels Eradicated from an Entire Pennsylvania Lake

David Hammond[1] and Gavin Ferris[2]
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In fall of 2017, a treatment protocol to eradicate invasive quagga mussels from an entire lake in Pennsylvania was executed by Earth Science Labs and Solitude Lake Management at the request of the Susquehanna River Basin Commission. The treatment consisted of 3 separate applications of EarthTec QZ, delivered over a period of 37 days. Mussel mortality was determined through use of caged adult mussels that were suspended at different locations and depths throughout the 29-acre lake. Mussels located above and below the thermocline – where water mixed well – were eradicated quickly, whereas those within the thermocline required follow-up, targeted treatment techniques and finally succumbed to 100% mortality 40 days after the initiation of treatment. Microscopic analysis of plankton tows and visual inspection of the shoreline after pump-down of the quarry in early November corroborated that all veligers and adults were successfully exterminated. Analysis of an eDNA sample taken in early December of 2017 also indicates the treatment was successful. The cumulative total copper applied throughout the entire course of treatment works out to 0.44 mg/L as calculated on the full volume of the lake. This is a historic case study because it represents the first recorded instance of a full-lake eradication of quagga mussels and is also the largest lake to have been eradicated of either quagga or zebra mussels.

Early Stages of Zebra Mussel *(Dreissena polymorpha)* Establishment in a Small, Temperate, Kettle Lake

★ **Stradder Caves and Dan Stich**
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Song Lake is a small, mesotrophic, kettle lake located in central New York State (NYS), with a surface area of approximately 110 acres and a maximum depth of 8 m. The first recorded sighting of zebra mussels *(Dreissena polymorpha)* was by stakeholders in September 2017. With a native species of unionid mussel, as well as a NYS threatened plant species, lake cress *(Rorippa aquatica)*, understanding the extent and size of the zebra mussel establishment has important management implications for this aquatic system in the future. Zebra mussel recruitment traps were placed at strategic locations around Song Lake at varying depths, and zebra mussel settlement was quantified by site and

depth during summer. Vertical plankton tows were performed at the location of each trap to capture veligers to quantify the theoretically number that are present in the system through the use of cross-polarized light microscopy. With Song Lake still being in the early stages of zebra mussel establishment, both the recruitment traps and the veliger tows can be useful in determining the extent of the infestation as well as potential management strategies going forward.

A Tale of Two Species: Aquatic Invasives in Butterfield Lake, New York

★ David Andrews[1] and Dan Stich[2]
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Butterfield Lake, New York is a 400-hectare meso-eutrophic body of water located in the Thousand Islands Region of New York State. By the year 2000 Eurasian watermilfoil *(Myriophyllum spicatum)* was prevalent, but not entirely dominant. Since then zebra mussels *(Dreissena polymorpha)* have also been observed by lakeside residents. Large areas of littoral habitat and a combination of fine organic sediment with areas of sheer rock outcrops suggest that these invasive species both could thrive within the lake and dominate the ecosystem. However, a survey on aquatic macrophytes in the year 2000 showed that a reasonable mixture of native plants and Eurasian watermilfoil existed in the lake. Zebra mussels are still relatively scarce and until this project no formal assessment of the population had been completed. We present an updated assessment of the aquatic macrophyte community, revisiting the sites surveyed in 2000 to determine any changes in composition. Additionally, we provide the first formal survey of zebra mussels in Butterfield Lake. Using a combination of physical and chemical characteristics of this lake, we suggest reasons for the unique progression of these two populations of invasive species over the past two decades.

Session A3: Alum Treatment

10:30 am – 12:00 pm | West Meeting Room 263

The Mystic(al) Lake Experience

Ken Wagner
Water Resource Services, Wilbraham, Massachusetts

Mystic Lake on Cape Cod in Massachusetts was one of the premier lakes on the Cape back in the 1980s and 1990s when nearby Hamblin Pond was under study and then restoration. Mystic Lake and the connected Middle Pond exhibited substantial deterioration over a 1–2 decade period, linked to low oxygen in deeper water and internal phosphorus loading, culminating in severe cyanobacteria blooms and a major mussel die off in 2009 and again in 2010. Aluminum treatment in early autumn 2010 reversed this trend, but not as well as in some other Cape Cod treatments. Issues included limitation on aluminum dose in the permit process, application at the end of a summer of intense P release from sediment and likely lower efficiency of treatment, and ongoing inputs from cranberry bogs and on-site wastewater disposal systems. Cyanobacteria blooms are less intense, water quality has improved, and the mussel community has undergone an impressive recovery, but the overall experience illustrates the tenuous nature of the three-legged stool of lake management. Science, economics and institutions interacted in this case to produce sub-ideal results. Lessons have been learned, but it is not clear that all those who need those lessons got them.

An Automated Low Rate Alum Addition System to Enhance Effectiveness of Wet Detention Ponds and Improve Lake Water Quality

Harvey Harper
Environmental Research & Design, Belle Isle, Florida

Wet detention ponds are one of the most common stormwater BMPs used today and provide load reductions of 20-40% for TN and 50-70% for TP, depending on design and detention time. Some projects need load reductions which exceed the capabilities of a wet detention pond, requiring the use of multiple BMPs. An alum-based system was developed to enhance the effectiveness of wet detention ponds which pumps water from the pond, samples the pH, and adds a low dose alum feed using a small variable speed metering pump. A venturi system injects microbubbles into the flow which incorporate into the floc as it forms. The water/alum mixture is discharged through an educator into a cone shaped device near the center of the pond. The air-infused floc migrates throughout the pond, removing algae and dissolved P before settling. The alum addition rate is based on the relationship between pH and algal growth and uses pH as a surrogate for nutrient levels. Alum is added automatically in proportion to the difference between the pond pH and the desired pH level. The pumping system activates daily, samples the pH, adds alum as necessary, and shuts off until the next day. Components for the system, including a 2,500 gallon alum storage tank, are located in a 200 sq. ft. open pavilion. The system operates automatically using a PLC, requires little attention, and can increase the effectiveness of a wet pond to > 70% for TN and > 90% for TP. This process can also be used on waterbodies directly, possibly allowing TMDL targets to be achieved without watershed BMPs.

Planning, Implementing, and Monitoring the Response of Minnesota's Largest Alum Treatment

Matt Kocian[1] and Joe Bischoff[2]
[1]Rice Creek Watershed District, Blaine, Minnesota; [2]Wenck Associates, Golden Valley, Minnesota

For more than 30 years, Bald Eagle Lake routinely experienced severe algae blooms. The lake was added to Minnesota's 303(d) List of Impaired Waters in 2002. Multiple diagnostic studies indicated that internal phosphorus loading was a significant portion of the annual phosphorus budget. To address internal loading, the Rice Creek Watershed District implemented the largest ever aluminum sulfate (alum) treatment in Minnesota history. Following the alum treatment, mean summer phosphorus and chlorophyll *a* concentrations decreased by 65% and 71%, respectively, while clarity improved by 64%; the improvements in water quality make the Bald Eagle Lake Alum Project a success story in lake management. However, the water quality metrics don't tell the whole story. Planning efforts began many years prior to project initiation, including aggressive management of curlyleaf pondweed. Creative financing – including a rarely-

used local tax district – was required to cover the project cost of more than $900,000. Logistical hurdles encountered during the project required operational flexibility. Perhaps most importantly, increased plant growth from improved water clarity created public backlash. Native aquatic plants increased in both distribution and density – including in highly-used recreational areas of the lake. Eurasian watermilfoil also increased, prompting new plant management activities by the Bald Eagle Lake Association. While the Bald Eagle Lake Alum Project is a success story, there are lessons to be learned about planning and implementing a lake restoration project of this scale, including improved public outreach and plain-language messaging.

Using an Adaptive Aluminum Sulfate (Alum) Application Approach to Improve Water Quality in Bald Eagle Lake, Minnesota

Joe Bischoff[1], William F. James[2], Brian Beck[1], and Matt Kocian[3]
[1]Wenck Associates Inc., Golden Valley, Minnesota; [2]University of Wisconsin–Stout Menomonie, Wisconsin; [3]Rice Creek Watershed District, Blaine, Minnesota

Bald Eagle Lake is a highly used recreational lake in the northern suburbs of the Twin Cities Metropolitan Area that routinely experienced cyanobacteria blooms. The Rice Creek Watershed District (RCWD) recently developed a targeted nutrient reduction program focused on achieving measurable improvements in lake water quality. One of the critical TMDL goals was quantify the roles of watershed and internal phosphorus loading in driving lake water quality. Laboratory-derived sediment P release was 10.8 mg/m^{2}d, representing 44% of the P load to the lake. The RCWD decided to pursue an aluminum sulfate (alum) treatment to reduce sediment phosphorus release. The targeted alum dose was approximately 100 g Al/m^2 based on laboratory jar tests. However, application of this rate throughout the lake was cost prohibitive. So, the 100 g Al/m^2 rate was used for areas greater than 20 feet in depth and a lower rate of 50 g Al/m^2 was used to inactivate the top 5 cm in the 15 to 20-foot depth zone. An adaptive alum application approach was used to achieve sediment aluminum targets and achieve the desired reductions in sediment phosphorus release. Half of the prescribed alum dose was applied to Bald Eagle Lake in the Spring of 2014 followed by sediment coring to measure changes in aluminum-bound phosphorus and sediment phosphorus release. Application zones and rates for the second (2016) application were adjusted based on the interim monitoring results. Following the completion of the alum applications Bald Eagle Lake is meeting State water quality standards for the first time is over 30 years.

Session: A4: Algal Toxins

10:30 am – 12:00 pm | West Meeting Room 264

Vertical Distribution of Cyanobacteria Toxins in Willow Creek Reservoir, Oregon

★ **Sarah H. Burnet and Frank M. Wilhelm**
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Blooms of cyanobacteria typically form unsightly surface scums which decrease a lake's aesthetics, decrease water clarity, shade other algal species in the water column, and challenge the normal feeding mechanisms of zooplankton and rotifers by clogging their filtering appendages, favoring small-bodies species which can alter fish communities. Additionally, cyanobacteria can produce some of the most potent toxins known to humans. Thus, the presence of toxic cyanobacteria can lead to the closure of water bodies due to harmful algal blooms (HABs) that cannot be removed via the usual means of water treatment. Typically, toxin samples are collected at the surface where cyanobacteria are present. What has received little research is the vertical distribution of toxins in the water column. This can be important for lakes and reservoirs in which i) the outflow depth can be- and is adjusted to meet downstream temperature criteria, or ii) is restricted to a single depth, and/or iii) serves as a source of potable or irrigation water. Research has shown that toxins in irrigation water can accumulate in plant tissue and can be subsequently transferred to consumers such as livestock. We tested the null hypothesis that cyanotoxins remained in surface waters in Willow Creek Reservoir (WCR), a strongly stratified reservoir in northeastern Oregon, that usually produces toxic blooms of cyanobacteria. We collected samples at bi-weekly intervals at multiple depths from the surface to one meter above the bottom of WCR and analyzed them for microcystin and nodularin concentrations using enzyme-linked immunosorbent assay (ELISA). While toxins were predominantly present in surface waters, on several occasions toxins were detected to depths of 3 and 6 meters. Additional samples and wind data are being collected in 2018 to reach definitive conclusions about the prevalence of toxins at depth and any implications for water use during such occurrences.

ELISA for Anabaenopeptins and Its Use for the Monitoring of Source Waters

Paige Ruthardt[1], Tom Glaze[1], Mark Aubel[2], Amanda Foss[2], and Fernando Rubio[1]
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Cyanobacterial harmful algal blooms occur in freshwater lakes, ponds, rivers, and reservoirs, and in brackish waters throughout the world. The wide variety of cyanotoxins and their congeners can lead to frequent exposure of humans through consumption of meat, fish, seafood, blue-green algal products and water, accidental ingestion of contaminated water and cyanobacterial scum during recreational activities, and inhalation of cyanobacterial aerosols. Cyanotoxins can also occur in the drinking water supply. In order to monitor

human exposure, sensitive analytical methods such as enzyme linked immunosorbent assay and liquid chromatography-mass spectrometry are often used.

Anabaenopeptins (APs) are cyclic peptides comprised of a ring of five amino acid residues connected to an exocyclic residue through an ureido linkage. Anabaenopeptins were first isolated from the cyanobacteria *Anabaena flos-aquae*. To date at least 96 anabaenopeptins have been reported, the various congeners are structurally related. *Planktothrix*, *Nodularia*, *Microcystis*, *Lyngbya*, and *Schizothrix*, have also been reported as producers of anabaenopeptins. APs have been shown to be inhibitors of protein phosphatases and carboxypeptidase A.

An ELISA for the monitoring of anabaenopeptins was developed and utilized for the detection of these toxins on 109 source water samples obtained from 30 midwestern sites during the 2016 to 2017 time period. The samples were also characterized for microcystins concentration by ELISA; and genes assays for mcyE, 16S, and sxtA by PCR. Nineteen of the samples were analyzed by PP2A, and by a LC/MS/MS method developed by Greenwater Laboratories. The results obtained indicate that anabaenopeptins are found at high concentration (up to 103 ppb) and at a high incidence rate. Details of the methods and data obtained will be presented.

From Algal Toxins to Environmental DNA: Passive Samplers as a Tool to Help with Multiple Management Objectives

Ellen Preece and Michael Bryan
Robertson Bryan, Inc., Elk Grove, California

As climate changes continue to affect aquatic ecosystems, it will be useful to streamline data collection protocols, so sampling tools can simultaneously address multiple management objectives while saving time and money. One currently used tool that shows promise are Solid Phase Adsorption Tracking (SPATT) samplers. SPATTs were developed as an economical tool to passively monitor algal toxins that may be missed by discrete grab sampling. We found SPATTs can also be used to monitor for Environmental DNA (eDNA). The eDNA method is a non-invasive, and relatively rapid process that can determine species presence and organism occupancy. Typically, eDNA monitoring involves collecting a discrete grab sample. However, traditional sampling methods may limit the spatial and temporal scale of eDNA monitoring. In a pilot study, we used SPATT and discrete grab samples to determine if imperiled freshwater mussels were present in the Sacramento-San Joaquin Delta (Delta). We deployed six SPATTs at two Delta locations. *Anodonta californiensis* were detected in all SPATT and grab samples at location 1. No mussel eDNA was detected in any SPATT samples at location 2, but *A. californiensis* was detected in 2 of 11 grab samples. This is the first time we are aware that SPATT samplers have been used to monitor for eDNA. Although we successfully used SPATTs, additional eDNA investigations and method modification may further improve upon our results. We believe SPATTs can be used to cost effectively detect cryptic or invasive species, while simultaneously monitoring for algal toxins in rivers, lakes, and reservoirs.

The Effect of Local Physical Lake Conditions on the Vertical Heterogeneity of Cyanobacteria and Microcystin in Stratified Eutrophic Lakes

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Cyanobacteria blooms are a ubiquitous ecological and public health risk as they have the potential to produce cyanotoxins, *i.e.*, microcystin. Prediction and management are imperative to mitigate these risks; however, cyanobacteria blooms are highly spatially and temporally variable making monitoring, managing and prediction difficult. A high frequency, high resolution, seasonal research station was deployed to quantify local meteorological conditions, water temperature, and water chemistry, including phycocyanin, in two different eutrophic stratified lakes. The monitoring effort was coupled with weekly sampling of microcystin concentrations (MC) throughout the water column. Our objective was to describe the vertical distributions of cyanobacteria biovolume (BV) and MC using physical lake parameters. A relationship was developed to predict the vertical stratification of cyanobacteria biovolume (BV) in the entire water column using the local temperature structure under a wide range of stratification conditions. We found that MC and BV accumulated above the thermocline and were highly correlated. There were two different BV distributions observed above the thermocline a) BV uniformly distributed over the diurnal surface mixed layer and b) local BV maxima both near and below the surface. A quantitative relationship was developed to predict the probability of observing of these distributions using local mixing parameters, specifically, a Reynolds number in the diurnal surface mixing layer. Understanding vertical distribution of BV and MC is important for monitoring and management efforts, because it narrows the range of BV and MC heterogeneity and suggests a more detailed vertical sampling protocol to detect potential maxima and representative concentrations.

Session A5: Army Corps Water Quality Activities

10:30 am – 12:00 pm | South Meeting Rooms 237–238

Understanding HAB Impacts at USACE Managed Reservoirs

Gerard A. Clyde, Jr.
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The US Army Corps of Engineers (USACE) manages 420 freshwater multipurpose reservoirs in 43 states. The authorized multiple purposes of these reservoirs can include some or all of the following: flood control, navigation, hydropower, water supply, conservation, low flow regulation, water quality control, fish and wildlife, and recreation. Since the mid-1990s USACE Districts have observed occasional and sporadic harmful algae blooms (HABs). In the early 2000s, USACE Districts in the contiguous United States began reporting an increasing frequency and intensity of HABs. Since 2005, the duration, magnitude, and persistence of HABs at USACE managed reservoirs are reported to be increasing in general however there is a great deal of geographic variability in these trends. USACE managed

reservoirs documented to experience HABs are located within the same geographic locations of USACE reservoirs documented to regularly deviate from authorized operational targets.

Remote Sensing Research to Support HAB Monitoring for the USACE

Molly Reif[1], Richard Beck[2], Min Xu[2], Richard Johansen[2], Erich Emery[3], Hongxing Liu[2], Susanna Tong[2], and Xi Chen[2]
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With increased threat and frequency of Harmful Algal Blooms (HABs), the US Army Corps of Engineers (USACE) Great Lakes and Ohio River Division (LRD) initiated a request to the USACE Water Operations Technical Support Program for investigation of remote sensing technology for inland water quality monitoring. Thus, an internal report was published, "Remote Sensing for Inland Water Quality Monitoring: A US Army Corps of Engineers Perspective" (Reif 2011), triggering a pilot project to demonstrate remote sensing capabilities for estimation of water quality indicators of HABs (*e.g.*, Chlorophyll *a*, Turbidity, and Blue-green Algae/Phycocyanin) in small, inland waterbodies. Project partners included the USACE (LRD, Louisville and Huntington Districts), the University of Cincinnati, the US Environmental Protection Agency, the Kentucky Division of Water, and the USACE Joint Airborne Lidar Bathymetry Technical Center of Expertise for the simultaneous collection of airborne imagery and *in situ* water measurements at Harsha (East Fork) Lake, Ohio and Taylorsville Lake, Kentucky in June 2014. These datasets have yielded subsequent analyses and publications evaluating numerous remote sensing algorithms applied to CASI hyperspectral imagery and derived imagery data, including simulated satellite sensor configurations for Worldview 2 and 3, Sentinel-2, Landsat-8, MERIS/OLCI, and MODIS. With LRD being steward to 90% of the nation's freshwater, including many small, inland waterbodies, remote sensing tools can serve to assist with prioritizing field-based monitoring and provide an early warning system. Recent research efforts will focus on deploying analytical approaches in an open-source software package containing a list of satellite-derived algorithms for the estimation of common HAB indicators.

Operating Flood Control Reservoirs to Maximize Recreation, Water Quality, and Fish and Wildlife Conservation

Andrew Johnson
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On average, the multipurpose lakes of the US Army Corps of Engineers, Huntington District, operate for flood control during 5% of the year. This leaves 95% of the year to optimize operations for other purposes such as water quality, recreation, fish and wildlife conservation, etc. The operation of these flood control reservoirs is dictated by a project's Water Control Plan which is often seen as a rigid set of rules that eliminate judgment calls during daily operations. Although these plans strictly dictate operations during flood fighting, there are, however, flexibilities built into the plans that allow lake managers to optimize operations for other authorized purposes. Recent Huntington District optimizations include temporal changes to operations, prioritization of water quality gates, minimization of cold water discharge pollution, implementation of e-flows, and alternate scheduling for winter drawdowns. These operational changes have resulted in better habitat for endangered mussels, increased recreational opportunities in the lake and downstream, more natural flow regimes and passage of basin sediments.

Advanced Modeling of Nutrients with HEC-RAS

Billy E. Johnson[1], Todd E. Steissberg[2], and Zhonglong Zhang[3]
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New advanced nutrient simulation capabilities have been developed and integrated within the Hydrologic Engineering Center's River Analysis System (HEC-RAS). Previous versions of HEC-RAS have had the capability to model temperature, the simplified nitrogen/phosphorous/algae cycle, and arbitrary constituents. The US Army Engineer Research and Development Center, Environmental Laboratory (ERDC-EL) has developed nutrient simulation modules (NSMs) for integration with a number for USACE hydraulic and hydrologic modeling systems however this presentation will focus on the integration of the modules with HEC-RAS. NSM I simulates algal biomass, organic and inorganic nitrogen and phosphorus species, biochemical oxygen demand and dissolved oxygen using ten state variables. NSM II, simulates multiple algal biomass, nitrogen, phosphorus, and carbon cycles, biochemical oxygen demand, dissolved oxygen, pathogen, alkalinity, and pH using twenty-two state variables, as well as numerous derived water quality constituents in the water column. In addition, a benthic sediment diagenesis model was included in NSM II and accounts for the deposition of organic matter from the water column to the sediment bed of the water body, its subsequent diagenesis or decomposition, and the flux of resulting end-products back to the overlying water column. Benthic sediments are represented as two layers, where three biodegradability classes of organic matter are simulated. This presentation will discuss the current state of model integration and case studies on the Minnesota River using the new model water quality capabilities.

Session A6: Data and Water Quality (WMAO)

10:30 am – 12:00 pm | South Meeting Room 233

Degration and Recovery of the Scioto River (Ohio-USA) Related to Reduction in Sewage Pollution Via Improved Wastewater Treatment 1979–2015

Chris Yoder
Midwest Biodiversity Institute, Columbus, Ohio

A 35+ year series of biological assessments in the Scioto River (Ohio-USA) since 1979 coinciding with wastewater treatment and water quality improvements firmly documents the role of

improved wastewater treatment. Nearly 100 fish species were virtually eliminated by gross sewage and industrial pollution in the 19th century and industrialization, urban development, and population growth through the 20th century. Despite the threats to public health and aquatic resources, little was done to abate gross pollution for nearly a century. The 1972 amendments to the Federal Water Pollution Control Act (aka Clean Water Act) forced better control of sewage and industrial pollution. However, biological recovery following reductions in gross loadings of untreated and poorly treated sewage took another 15–20 years to fully emerge. Improvements were incremental with full recovery taking another 10–15 years. Maintenance of this level of water quality is assured by discharge permits and prohibitions against relaxing the highest water quality achieved after a permit is issued. A strong implication of these observations is that water pollution controls installed in the 1980s have emerged in the form of improved biological integrity that is now closer to pre-settlement conditions than at any time since the European settlement of the Midwestern US. The restoration success of Scioto River and its documentation resulted from CWA driven WQS and treatment technology and requirements for ambient monitoring. Serious doubts existed about the attainability of advanced wastewater treatment technology and meeting WQS in an effluent dominated river, but these doubts have since been erased by the demonstrated improvements in the biological assemblages not only in the Scioto River, but many other rivers throughout Ohio. Advanced treatment technologies are now regarded as the default requirement for any new wastewater treatment facility making the attainment of aquatic life based WQS attainable.

Leveraging DNA to Enhance Water Quality

Mauricio Larenas
Source Molecular Corporation, Miami, Florida

Stormwater managers face increasing pressure to keep waters clean from untreated discharges. DNA profiling has become the gold standard in industries such as forensic science. Microbial source tracking (MST) helps stormwater managers determine where fecal pollution is coming from, pinpoint the host responsible for the fecal pollution, and evaluate BMP effectiveness.

The presentation includes a discussion on two MST projects in Massachusetts and California. Geosyntec conducted a project for the Boston Water and Sewer Commission in which they used DNA markers to assess the effectiveness of Boston's MS4 IDDE program in storm water and other water systems. Santa Barbara in California used MST to identify host fecal contamination sources that polluted their beaches through storm water systems. Santa Barbara conducted a follow-up MST study to evaluate the impact of the structural and non-structural best management practices (BMPs) deployed to mitigate this fecal pollution.

Keeping an Eye on Water Quality in the Great Miami River Watershed

Sarah Hippensteel Hall and Scott Bell
Miami Conservancy District, Dayton, Ohio

Water quality and quantity challenges occur regardless of political or jurisdictional boundaries. This session will make the case for statewide investment in water protection and restoration. Local communities view the Great Miami River as a valuable community asset worthy of investment. Today, the Great Miami River is one of the healthiest waterways in Ohio. The Ohio Environmental Protection Agency reports that water quality improvements rank as some of the most significant improvements observed for any Ohio river or stream (US Army Corps of Engineers 2014). Recent investment in riverfront recreation in and along the Great Miami River is more than $100 million and growing. Recent economic development investment in riverfront communities of commercial, retail, and residential is more than $500 million and growing. The communities in the Great Miami River recognize the potential to maximize existing and planned riverfront investments and economic development by approaching the river corridor as a unified, connected, regional place. A 2014 USACE study of the Great Miami River benchmarked rivers around the US, noting the more that a river corridor is known by a well-articulated and unifying identity – the more investment of both private and public funds is directed at projects that produce quality-of-life gains as well as economic returns and improved conservancy or important land and water habitats. Without a healthy waterway, the return on these investments could be severely diminished. The Miami Conservancy District is working with many partners to advocate for investment in the protection and improvement of rivers and groundwater. (MCD has worked to create meaningful change at a watershed scale for 100 years. Over those years, MCD helped communities deal with many water issues including flood protection, wastewater treatment, river recreation, groundwater protection, stormwater regulations, nutrient pollution, and most recently, economic development.)

Nutrient Mass Balance Study for Ohio's Major Rivers

Josh Griffin
Ohio EPA, Columbus, Ohio

A nutrient mass balance was completed for nine watersheds in Ohio covering 66 percent of the state's land area in April of 2018. The watersheds studied were in both the Lake Erie and Ohio River drainages. The objective of the study was to determine nutrient (phosphorus and nitrogen) loads and relative proportions of point and nonpoint sources. The study highlights differences between the watersheds both as total loads and relative contributions from different sources in the watersheds. This is the second biennial iteration of this report and now includes five years of data. Opportunities are identified for future data collection and new approaches that can refine the analysis.

Session A7: Waterways and Infrastructure (WMAO)

10:30 am – 12:00 pm | South Meeting Room 236

Two Birds with One Stone: Funding Flood Mitigation and Infrastructure Repair with FEMA HMGP

David Hayson
Stantec Consulting Services Inc., Cincinnati, Ohio

Sharonville, Ohio is at risk of riverine flooding from the Sharon Creek Tributary due to runoff from large storm events. FEMA's Flood Insurance Rate Map reveals areas of concern for the City and its constituents as a large portion of the downtown area is within the 1%-Annual-Chance floodplain extents (100-Year). The potential flooded areas include several residential properties and commercial buildings. Damaged infrastructure, transportation impacts, and reduced economic activity are anticipated due to flooding events. High flood insurance premiums frustrate the community and deter economic vitality/growth for the City of Sharonville.

Sharonville collaborated with Stantec to conduct hydrologic and hydraulic analyses of the Sharon Creek Tributary watershed. The modeling results exposed vulnerabilities and deficiencies with the conveyance of the existing culvert under Main Street and storm water management in the watershed. Stantec identified two mitigation activities that in combination reduce the risk of flooding in Sharonville by up to four feet for the 1%-Annual-Chance flood. The proposed culvert removal and dam spillway modifications had an estimated cost of $2.6 Million with more than $3.9 Million in expected benefits.

With a proposed project and positive benefit-cost relationship, Stantec worked with Sharonville to identify funding opportunities. Ultimately, the City was awarded a FEMA Flood Mitigation Assistance grant with local match funding coming through the Ohio Department of Transportation, the owners of the culvert. When constructed, the proposed improvements will remove the majority of downtown Sharonville from the regulatory floodplain with limited costs to the City.

Indian Lake Labyrinth Spillway – Improving the Efficiency of a Historic Spillway

Rob Kirkbride
Stantec, Columbus, Ohio

The Indian Lake Dam and Spillway, owned by the Ohio DNR and located in Russells Point Ohio, creates Indian Lake, the principal feature in Indian Lake State Park. The 150+ year old dam was in need of rehabilitation to address inadequate spillway capacity and severe concrete deterioration of the 700-foot-long ogee spillway. The primary focus of this presentation will be the replacement of the ogee spillway with a two-stage labyrinth spillway.

The labyrinth style spillway simulates the original 700-foot-wide spillway within a reduced 180-foot-wide spillway section. The additional spillway length created now serves as an auxiliary spillway for storms that exceed the 100-year event. Construction was performed in a manner that did not impact the normal operating lake level to allow for continued recreational activities. Numerous photos and videos will be presented to show the unique structure and techniques used during this project.

The Green Monster: A Case Study on Earth Dam Landslides, Hidden Valley Lake Dam, Dearborn County, Indiana

Peter Soltys
Fishbeck, Thompson, Carr & Huber, Inc., Cincinnati, Ohio

The Hidden Valley Lake Dam located within the Hidden Valley Lake Community in Dearborn County, Indiana, has experienced a series of shallow landslides on its downstream face since the dam was completed in 1972. The latest landslides occurred in 2011, 2012, and 2018 and reflect problems related to the earth embankment construction materials, the steepness of the downstream slope, and weather conditions. This presentation discusses the conditions at the dam resulting in landslides, recognition of the problem by the owner, the owner's emergency management response, long term monitoring responsibilities of incidents/safety deficiencies, the need for preparedness, the close working relationship with an engineer and local emergency responders, and handling the public during dam emergencies.

Ice Jam Awareness

Thomas Harris
US Geological Survey, Columbus, Ohio

The US Geological Survey operates and maintains river gages throughout the United States. As part of the operation of the gage, the USGS also makes routine streamflow measurements at these sites. For the northern tier states, these rivers often freeze solid, however that does not stop the USGS from making flow measurements under ice covered conditions, called ice measurements. During the winter of 2018, the USGS has made over 20 ice measurements in Ohio. These ice measurements are important to make as ice cover in the stream tends to give a higher stage for a given flow than if the stream was not ice covered. An important piece of information while making an ice measurement is the ice thickness. This winter, ice thickness were relayed to the National Weather Service offices in Wilmington and Cleveland, Ohio so they could produce more accurate river forecasts when ice finally does break up and flood towns and communities.

During the fall 2017, as part of the Silver Jackets Team, Thomas Harris from the US Geological Survey, along with Sarah Jamison from National Weather Service Cleveland gave an Ice Jam Awareness presentation to two communities in the Cleveland area and one community in Toledo. Harris presented what it takes to form ice on streams and presented a case study of ice formation on the Conneaut River near Conneaut, Ohio. Jamison outlined the efforts of the National Weather Service in trying to predict river stage on an ice covered stream.

During the winter of 2018, ice jams affected the communities of Zanesville, Painesville, Milan and Vermilion, Ohio.

Session B1: Large Data Sets and Long-Term Monitoring

1:30 pm – 3:00 pm | West Meeting Rooms 260–261

Changes in Water Quality Across a Longitudinal Gradient in Lake Lemon, Indiana: A 20-Year Perspective

★ **Cory Sauve**
Indiana University, Bloomington, Indiana

Reservoirs are unique aquatic systems as they exhibit both lotic and lentic characteristics across a longitudinal gradient. The process in which a reservoir transitions from a riverine to a lacustrine system has implications on the physical, chemical, and biological conditions throughout the reservoir. Since 1998, the Indiana Clean Lakes Program (InCLP) has monitored Lake Lemon, a 1,650-acre reservoir located near Bloomington, Indiana. Sampling was conducted during the growing season (May–August) for each year at sites located across the longitudinal gradient of the reservoir. In this study, I will use the long-term monitoring data to summarize water quality changes for Lake Lemon over two decades and identify if the sampling sites illustrate a longitudinal gradient in the reservoir. The results of this study will contribute to the overall understanding of the various limnological processes influencing water quality in Lake Lemon, and the importance of sampling design when monitoring reservoirs.

Long-Term Limnological Response to Management of Internal Phosphorus Loading and Curly-Leaf Pondweed in Half Moon Lake, Wisconsin

William F. James
University of Wisconsin–Stout, Menomonie, Wisconsin

Half Moon Lake, a shallow oxbow cutoff located in Eau Claire, Wisconsin, has been the subject of multiple management practices over the last decade to reduce cyanobacteria blooms and abundant curly-leaf pondweed. To control internal phosphorus (P) loading, the west arm was treated with 150 g/m^2 to inactivate redox-P on the order of 1–5 mg/g while the east arm was treated with 75 mg/g to bind much lower redox P in 2011. While limnological response variables improved substantially over the first 3 years post treatment, declining P binding efficiency and P diffusion through the Al floc layer resulted in recovery of internal P loading and rebounding cyanobacterial blooms (James 2017). A second Al application of 50 g/m^2 to the west arm sediments in 2017 has suppressed diffusive P flux from sediments and resulted in much improved summer limnological conditions. Curly-leaf pondweed (CLP) has been controlled for nearly 10 years starting in 2009 with low-dose endothall applications in the Spring to suppress turion production. Since CLP populations have dominated the macrophyte community assemblage for decades, the turion seed bank has been difficult to deplete. Native macrophyte biomass response to management, primarily as *Elodea*, appeared to be most sensitive to underwater light habitat versus CLP management. However, native biomass relationship to summer Secchi transparency and PAR attenuation was weak suggesting other factors like winter snow cover extent and duration may also be influencing *Elodea* growth.

25 Years of Water Quality Change in Rhode Island Lakes and Ponds

Betty Kreakie[1], Dorthy Kellogg[2], Jeff Hollister[1], Stephen Shivers[3], Elizabeth Herron[4], Linda Green[4], and Art Gold[2]
[1]US Environmental Protection Agency, Office of Research and Development, Narragansett, Rhode Island; [2]University of Rhode Island, Kingston, Rhode Island; [3]US Environmental Protection Agency, Office of Research and Development ORISE Fellow, Narragansett, Rhode Island; [4]University of Rhode Island Watershed Watch, Kingston, Rhode Island

The University of Rhode Island's Watershed Watch Volunteer Monitoring Program has been collecting water quality data on dozens of Rhode Island lakes and ponds for over 25 years, allowing exploration of long-term trends in common water quality parameters. Not all lakes and ponds in the study area were sampled across the full time period and lakes were often added in geographic clusters (*e.g.*, in urbanized northern Rhode Island). Similar to how long-term temperature records are analyzed, we centered and scaled (*i.e.*, the z-score) water quality measurements on a per-station basis. This provides a robust and commonly scaled measurement to explore this data for long-term trends. State-wide aggregation of all lakes showed increasing temperature, chlorophyll *a*, and total nitrogen. Interestingly, total phosphorus is showing a decline, perhaps reflecting the management focus on phosphorus reductions. While yearly trends are useful, they do mask month-to-month variability differences across sites. Additionally, while most sites track the yearly trend in decreasing water quality, there are bright spots with a few sites improving over the 25 years. Contrary to previously reported analyses that show relatively stable water quality at the regional scale, our analysis shows that long-term water quality trends within Rhode Island show some parameters improving while others are in decline. Importantly, this analysis also points out the value and importance of data from long-term monitoring programs, like URI Watershed Watch, for identifying trends in environmental condition.

The Importance of Nutrient Supply by Fish Excretion and Watershed Streams to a Eutrophic Lake Varies with Temporal Scale Over 19 Years

★ **Tanner J. Williamson[1], Michael J. Vanni[1], María J. González[1], William H. Renwick[2], Mary T. Bremigan[3], and Joseph D. Conroy[4]**
[1]Department of Biology, Miami University, Oxford, Ohio; [2]Department of Geography, Miami University, Oxford, Ohio; [3]Department of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan; [4]Ohio Department of Natural Resources – Division of Wildlife, Columbus, Ohio

Animals can transform and translocate nutrients at ecologically relevant rates, likely contributing to eutrophication in aquatic ecosystems by mobilizing otherwise unavailable nutrients. Yet we know little about how animal-mediated nutrient cycling compares to abiotic nutrient sources over long periods and across multiple timescales. To address this, we conducted a 19-year study in a eutrophic reservoir (Acton Lake, Ohio, USA), examining

nitrogen (N) and phosphorus (P) inputs from watershed streams versus excretion by an abundant fish (gizzard shad, *Dorosoma cepedianum*) across a range of temporal scales.

Watershed loading was the dominant nutrient source at annual timescales. However, fish excretion frequently exceeded watershed loading summed over the growing season and over summer, when algal biomass is highest and algal nutrient limitation is most severe. Fish excretion was a more consistent nutrient source, with much lower temporal variability in both supply rate and N:P ratio. Indeed, aggregate nutrient supply (watershed loading plus fish excretion) was much less variable for both loading rate and N:P ratio. Fish excretion also supplied nutrients at a much lower N:P ratio than the watershed.

In eutrophic lakes, where fish biomass is often high, fish excretion can strongly influence algal biomass and community composition. Eutrophication management efforts should consider removal of benthivorous fish, like gizzard shad, in addition to other watershed management practices to improve water quality. Future climate change will likely modulate the interplay between fish- and watershed-mediated nutrient dynamics by altering the geographic distribution of detritivorous fish and the frequency and severity of storm and drought events.

Session B2: Macrophyte and Periphyton Monitoring and Management

1:30 pm – 3:00 pm | West Meeting Room 262

Wild Rice AWQMS Project Case Study

Nancy Schuldt[1] and Alex Heppner[2]
[1]Fond du Lac Environmental Program, Cloquet, Minnesota; [2]AWQMS, Salt Lake City, Utah

Native people have been harvesting rice for many hundreds of years in the upper Midwest; it is essential to their subsistence culture, diet, and traditions. With multiple stressors potentially impacting wild rice, tribes would greatly benefit from simple, straightforward tools to manage wild rice data and facilitate data analysis to examine how these stressors are affecting wild rice, both temporally and spatially. Because of natural annual fluctuations in wild rice stands, wild rice must be monitored over multiple years to encompass this natural variability. Some tribes and tribal agencies in Region 5 currently collect data on wild rice waters, including water quality and sediment quality, stand density and abundance, but the methods, parameters measured, and monitoring frequency are not uniform.

Tribal Wild Rice Production and Water Quality Data Management and Analysis Project was launched in October of 2013 and is ongoing. The main goal was to provide a single online information system for consolidating, vetting, tracking and analyzing such data across tribal boundaries. Another major goal was to provide water quality data to the EPA's Water Quality Exchange (WQX) while also providing insight into how EPA could better model such vegetation production data. This presentation will walk through a case study using real data and simultaneously demonstrate all of the items that were implemented in order to achieve the goals of the project.

Early Operational Use of ProcellaCOR for Selective Control of Invasive Aquatic Plants

Mark Heilman
SePRO, Carmel, Indiana

ProcellaCOR™ Aquatic Herbicide (a.i. florpyrauxifen-benzyl) received its USEPA registration in February 2018. It is the first new herbicide approved by USEPA with an aquatic use as part of its initial registration since 1986 (Sonar®). The EPA Reduced Risk technology has novel, low-rate (100× lower than older technology), selective, systemic activity on major US aquatic invasive weeds including hydrilla, Eurasian and hybrid Eurasian watermilfoil, floating hearts, parrotfeather, and water hyacinth. This presentation will highlight results of quantitative vegetation assessments (point intercept and hydroacoustic) and dissipation monitoring of early operational management with ProcellaCOR. The field studies during the summer of 2018 are being collaboratively conducted by private and public research teams to document selective control outcomes with the new herbicide across a number of major US invasive weed species.

Bridging the Data Gap Between Spring Nutrient Input and Summer Periphyton Growth Via Bay Sediment Delivery and Retention Analysis in Coeur d'Alene Lake, Idaho

★ **Randi Notte[1], Frank Wilhelm[1], and Craig Cooper[2]**
[1]University of Idaho, College of Natural Resources, Moscow, Idaho; [2]Idaho Department of Environmental Quality, Coeur d'Alene, Idaho

Lake littoral zones are key focus areas to predict change in lake trophic status due to their proximity to incoming sources of sediment and associated nutrients. Here, periphyton are excellent candidates as indicators to evaluate nutrient loading because they are stationary, and their growth reflects the arrival of nutrients to them, unlike free-floating algae that can obtain nutrients from different parts of the water column. In a study in 2017 of periphyton communities in six northern bays of Coeur d'Alene Lake (CDA, Idaho, USA) to test the hypothesis that their growth and density would reflect bay watershed disturbance by human activity, which also varied among the bays, we found similar growth patterns and climax densities which did not support our hypothesis. Our results also were inconsistent with those from another local lake in which rapid periphyton growth and high climax densities were directly related to human impact in the sub-watersheds. To further investigate the periphyton response to nutrient loading in Lake CDA in 2018, we characterized sediment and nutrient loads to two end-member bays (low and high human watershed disturbance) that were similar in bathymetry and shoreline housing density. We also characterized periphyton growth and retention time in each bay to explore if retention could explain the differences observed in 2017. Variation in nutrient load to bays of Lake CDA may be masked by different bay-specific retention regimes, thereby explaining the similar periphyton responses. This has important implications of how to make periphyton growth an effective indicator of loads to lakes.

The Life History of *Nectopsyche albida* and Its Dietary Habits in Coeur d'Alene Lake, Idaho, With a Focus on Predation on Invasive Eurasian Milfoil

★ **Stephanie Estell[1], Ben Scofield[2], and Frank M. Wilhelm[1]**
[1]University of Idaho, Moscow, Idaho; [2]Lake Management Department, Coeur d'Alene Tribe, Plummer, Idaho

Invasive Eurasian watermilfoil *(Myriophyllum spicatum)* and a hybrid watermilfoil *(M. spicatum x M. sibiricum)* can be a nuisance in water bodies for recreational swimmers and boaters and reduce the diversity of native macrophytes. Lake Management Department staff of the Coeur d'Alene Tribe have noticed substantial damage to *M. spicatum* in areas where the caddisfly, *Nectopsyche albida*, was present in high abundance. This led us to formulate the hypothesis that *N. albida* is a natural herbivore of *M. spicatum* and the hybrid watermilfoil. Because these observations occurred in Coeur d'Alene Lake, this would be a range extension for *N. albida*, and its life history pattern within this range extension is unknown. We first examined growth, instar succession, and emergence to establish baseline parameters. Concurrently we examined the diet of *N. albida* using stable isotopes of carbon and nitrogen to determine its food source. We also undertook feeding trials to examine preference between two species of macrophytes (*M. spicatum* and *E. candaadensis*) and trials to determine rates of consumption. Life history analysis showed that *N. albida* was uni-voltine, while stable isotope analyses revealed it consumed the macrophytes. The feeding trials seemed to show preference for one of the macrophytes, and suggested consumption rates were approximately two leaves per individual per day. Further research is needed to understand the relationship between life history, density, and consumption of *M. spicatum* to determine if *N. albida* could serve as a biological control agent.

Session B3: Hydrology and Hydrodynamics

1:30 pm – 3:00 pm | West Meeting Rooms 263

The Role of Morphometry and Hydrology in Promoting Eutrophication and Harmful Algal Blooms in Reservoirs

Reed Green[1], Anne Hoos[2], Alan Wilson[3], and Victor Roland[2]
[1]US Geological Survey, Little Rock, Arkansas; [2]US Geological Survey, Nashville, Tennessee; [3]Auburn University, Auburn, Alabama

Reservoirs store "legacy" phosphorus in trapped sediment that washes off the surrounding landscape. Historically, internal phosphorus loads in reservoirs have been considered "decimal dust" relative to the large external loads delivered from the contributing watershed. Internal loading occurs under anoxic conditions when stored phosphorus is released from bed sediments and transported to the photic zone during mixing events which promotes algal growth and blooms during the summer thermal stratification season. In this study, the US Geological Survey examined the use of six water-body morphometric measures, hydrology based on a flushing rate, and external nutrient (nitrogen and phosphorus) loads and concentrations as predictors of Secchi depth and concentrations of chlorophyll *a* and microcystin in 114 natural lakes, 183 headwater reservoirs, and 61 reservoirs downstream of an upstream control structure. All lakes and reservoirs are greater than 0.1 km^2 and are located within the eastern United States (National Hydrography Data Set, major river basins 1 and 2). Results will provide a basis for examining the susceptibility of natural lakes, headwater reservoirs, and downstream reservoirs to eutrophication and susceptibility to harmful algal blooms.

Small Reservoir Water Level Management

Clayton Morlock[1], Greg Dutson[2], and Tim Newton[2]
[1]Canary Systems, New London, New Hampshire; [2]Canary Systems, Chattanooga, Tennessee

Tools are discussed for monitoring and controlling water levels at small reservoirs with a case study provided for Pleasant Lake of New London, New Hampshire. The level of complexity of the monitoring systems depends on the criticality of maintaining the desired level and the necessity of controlling the discharge rate below the dam. In this case study, automated monitoring techniques are used for observing water levels, discharge gate openings amounts, and weather (precipitation and temperature). Using these measurements in combination with readily available regional rainfall and historical hydrologic information, both water recharge and discharge rates can be approximated. Bathymetric surveys are used to determine holding capacities at various pond levels. Remote sensing data from satellites can be used to observe factors that affect recharge such as soil saturation and snow cover for the drainage area. With a good hydrologic model and weather predictions, informed preemptive drawdowns can be made to mitigate adverse effects from severe weather events or spring thaws before they happen. Regulatory compliance for dam safety can be facilitated by using the stored monitoring system data. As more data is gathered, the hydrologic models can be further refined to improve operational predictions. Automated control of pond levels can be incorporated with safeguards put in place for manual override. Information is stored in a central georeferenced database to facilitate analysis and display. Lake health and safety data can be stored in the same georeferenced database. Lastly, information and procedures can be stored and implemented for an emergency action plan.

Hydrodynamic Simulation of Lake Mead to Inform Future Drinking Water Treatment Needs

Deena Hannoun Giffen and Todd Tietjen
Southern Nevada Water Authority, Las Vegas, Nevada

Lake Mead is a large reservoir along the Colorado River that supplies water for drinking and irrigation to nearly 30 million users. Persistent drought conditions have caused a sharp decline in the elevation of Lake Mead, and consequently, a new drinking water intake was constructed at a lower elevation to bolster the water supply to the Las Vegas Valley. As lake levels decline, sediment coming downstream from the Colorado River has the potential to enter the drinking water intake, causing turbidity issues and thus affecting water treatment. To plan for future treatment scenarios, we use the 3D hydrodynamic and water quality model AEM3D to study the effect of lake levels on sediment loads at the Southern Nevada Water Authority's drinking water intake in Lake Mead. Sediment particle sizes

and concentrations were determined by fitting a distribution to data collected upstream during high flows. These simulated particle distributions are transported downstream using the hydrodynamic component of AEM3D, and the concentration at the drinking water intake is recorded daily. Simulations were performed over a period of 10 years to quantify seasonal variations, meteorological effects, and long-term effects on the lake. The output of the full AEM3D model is then emulated using a simpler model, which will eventually serve as the initial condition for a water treatment plant model.

Watershed Management-Expanding the Nonpoint Source Horizon for Better Results

Russ Gibson
Coldwater Consulting, LLC, Galena, Ohio

Habitat alteration, hydromodification, silt/sediment and nutrients are the four highest magnitude nonpoint source causes of aquatic life use impairment in the state of Ohio. The two most common causes are hydromodification and habitat alteration! Yet watershed management for many folks consists of trying to encourage farmers to implement best management practices such as filter strips, cover crops and others. Despite decades of state and federal funding for source reduction BMPs, we have yet to see the kinds of pollutant reductions that are needed to meet Ohio's water quality goals.

State agencies and local watershed groups spend a great deal of time (and money) developing water quality plans such as TMDLs and 9-element watershed plans. A key component to both processes is identifying those critical areas within a watershed that are contributing disproportionate loads of pollutants. These plans also identify those areas where direct modifications to natural flow such as lowhead dams and channelization further impair a stream's assimilative capacities. Focusing implementation on all of these critical areas and marrying the right practice to the problem are critical if we are to maximize water quality benefits.

This presentation encourages broadening the suite of watershed management activity that must be brought to bear if we are to achieve improved water quality. The decades-old emphasis on source reduction agricultural BMPs is good and provides an important tool for engaging farmers. However, effective watershed management requires a comprehensive approach, one that includes implementing activities such as removing lowhead dams, breeching dikes and levees, capturing nutrient laden runoff in restored wetlands and others. Mr. Gibson will share success stories and examples where this comprehensive approach resulted in considerable water quality improvement.

Session B4: Algal Toxins

1:30 pm – 3:00 pm | West Meeting Room 264

Toxic Toledo and Maumee Microcystis: Was the Unprecedented cHAB in 2017 Lake or River Derived?

Douglas Kane[1], Thomas Bridgeman[2], Robert McKay[3], Timothy Davis[3], George Bullerjahn[3], Gregory Boyer[4], and William Cody
[1]Defiance College, Defiance, Ohio; [2]University of Toledo, Toledo, Ohio; [3]Bowling Green State University, Bowling Green, Ohio; [4]SUNY-ESF, Syracuse, New York

Cyanobacterial Harmful Algal Blooms (cHABS) have been resurgent in Lake Erie during the past two decades, however; less is known about the occurrence and toxicity of cHABS in the Maumee River. Although, previous studies in the last decade have found abundant cyanobacteria in the river, few found appreciable amounts of toxin-producing strains or toxins in the river. However, in September 2017, a microcystins-producing bloom of *Microcystis* occurred in downtown Toledo on the Maumee River. We used a Fluoroprobe to determine algal biomass at a coarse taxonomic resolution, ELISA to test total microcystins of river water samples, and LC-MS analysis to determine the presence of three microcystin congeners (MC-LR, YR, and RR). Samples taken during the large late-September cHAB bloom in the Maumee River near downtown Toledo possessed measurable microcystins (with MC-LR the predominant congener), with 9 out of 13 sites sampled exceeding the Recreational Public Health Advisory level (6 µg/L total microcystins) and 6 of 13 sites sampled exceeding the Elevated Recreational Public Health Advisory (20 µg/L total microcystins). Herein, we elucidate whether this highly toxic bloom was of lacustrine or riverine origin using genomic data.

Maximum Microcystin Concentrations in Western Lake Erie Predicted by Early Season Nutrient Concentrations

Darren Bade
Kent State University, Kent, Ohio

Microcystin has been a primary concern related to harmful algal blooms in western Lake Erie. While the extent of algal blooms in Lake Erie has been well predicted by models using spring nutrient loads, no annual predictions related to bloom toxicity exist. Moreover, a large bloom extent does not necessarily equate to high bloom toxicity. Using data collected by the Ohio Environmental Protection Agency at 25 sites in western Lake Erie between 2011 and 2015, microcystin concentrations were compared with nutrient concentrations to explore possible relationships and build predictive models. This data set, which contains nearly 350 observations, confirmed a basic relationship between algal biomass (as Chlorophyll *a*) and microcystin concentration (Pearson's $r = 0.67$, $p < 0.001$). The maximum concentration of total phosphorus, dissolved reactive phosphate, or nitrate at a site early in the season (before July) explained a large portion of the variation in the maximum microcystin concentration which occurs later in the season (*e.g.*, for TP, $R^2 = 0.70$). The model was used to predict microcystin concentrations

at eight sites in 2016. In that year, the model tended to underestimate the maximum microcystin concentrations, but all sites except one were within the prediction errors. Other qualitative aspects of the data set may also aid in predicting toxin dynamics. When ammonium is present at detectable concentration, microcystin tends to be low or undetectable. Microcystin concentrations tend to peak when nitrate is still present and then declines after nitrate becomes undetectable.

Cyanobacterial Blooms and Toxin Production in Lower Green Bay, Lake Michigan

Gina LaLiberte[1], Sarah Bartlett[2], Erin Houghton[2], Donalea Dinsmore[1], Todd Miller[3], and Dawn Perkins[4]
[1]Wisconsin Department of Natural Resources, Madison, Wisconsin; [2]NEW Water Green Bay Metropolitan Sewerage District, Green Bay, Wisconsin; [3]Zilber School of Public Health, University of Wisconsin–Milwaukee, Milwaukee, Wisconsin; [4]Wisconsin State Laboratory of Hygiene, University of Wisconsin–Madison, Madison, Wisconsin

Cyanobacterial blooms occur frequently in Green Bay. Surveys of toxin production by cyanobacterial blooms in the bay have been limited, despite Green Bay's listing as a Great Lakes Area of Concern under beneficial use impairments (BUIs) which include Eutrophication or Undesirable Algae and Beach Closings or Recreational Restrictions. In order to assess the Beach Closings BUI, we have investigated cyanobacterial community composition, toxin production, pigments, and water quality parameters at 2 beach sites, the mouth of the Fox River, and 5 offshore sites in Lower Green Bay since 2016. We will present seasonal trends in the algal and cyanobacterial community and cyanobacterial toxin production, and their implications for primary contact recreation based on draft US EPA cyanotoxin swimming advisory guidelines.

Safety and Decontamination Protocols When Sampling Blooms of Cyanobacteria: What's Being Done in the Real World, and What Some Institutions are Requesting to Approve Research

Frank M. Wilhelm and Sarah H. Burnet
Department of Fish and Wildlife Sciences, University of Idaho, Moscow, Idaho

Sampling blooms of cyanobacteria for the analysis of toxins presents a conundrum. A bloom could be toxic, in which case some safety measures should be employed to protect those taking samples, however, beyond wearing gloves, additional PPE on a hot day in August becomes cumbersome and, in some cases, *i.e.*, full-face respirator, downright unbearable, or dangerous if operating a motorboat. This is compounded by the fact that the status of the samples (toxic or non-toxic) is unknown *a priori*. Because we were requested by our Institutional Biosafety Committee, which reviews proposals, to develop a decontamination protocol and complete a biosafety manual before students could drive a boat on a lake with a history of toxic blooms of cyanobacteria, for a project unrelated to cyanobacteria, we surveyed individuals around the US that are currently actively engaged in HABs research to learn of their PPE procedures and decontamination protocols. Overwhelmingly, use of gloves 'when it looked bad' was the only PPE measure employed. For decontamination of gear (boats, trailers, etc.), draining and drying (exposure to sun and UV) were the only procedures used. None of these procedures were documented in a citable format. Our goal here is to engage the audience to extend our sample size, to produce a note in LRM that provides a citable source for those required to complete PPE and biosafety manuals to work on lakes/reservoirs with known blooms of toxic cyanobacteria.

Session B5: Shallow Lakes

1:30 pm – 3:00 pm | South Meeting Rooms 237–238

Part I: Improving the Water Quality of an Urban Shallow Lake and then Navigating the Response

Bill Bartodziej[1] and Keith Pilgrim[2]
[1]Ramsey-Washington Metro Watershed District, Little Canada, Minnesota; [2]Barr Engineering, Edina, Minnesota

Kohlman (36 ha, mean depth of 1.2 m) is the northernmost lake of the Phalen Chain of Lakes in the Twin Cities, Minnesota. In 2008, Kohlman was placed on the Minnesota Pollution Control Agency's 303(d) Impair Waters List for total phosphorus (P), due to a ten-year growing season mean of 98 µg/l. Mass balance modeling suggested that reductions of 95 kg (22%) of P from watershed loading and 116 kg (88%) from internal loading would bring P concentrations down below 60 µg/l (state standard) in the lake. In 2009, the Ramsey-Washington Metro Watershed District (RWMWD) began to implement watershed and in-lake P management practices. Two doses of aluminum sulfate and sodium aluminate were applied to the lake bottom substrate by using a barge. In 2009, common carp *(Cyprinus carpio)* biomass was estimated at 180 kg/ha. Biomass over 90 kg/ha often has negative impacts to water quality. Through commercial fishing, baited box netting, and management of nursery areas, the carp population was reduced to 45 kg/ha. In addition, several large stormwater management projects were completed in the Kohlman watershed. Collectively, these efforts have resulted in seasonal means for P, chlorophyll *a*, and Secchi depth being below the standards set for Minnesota shallow lakes. With the improved water transparency, aquatic plants responded by increasing in abundance. So much so that the RWMWD conducted experimental aquatic plant harvesting operations. Lakeshore owners are now grappling with the increased aquatic plant cover, and the RWMWD is determining how to best support thoughtful and effective aquatic plant management.

Part II: Evaluating the Effect and Potential Benefits of Mechanical Harvesting on Aquatic Plants and Phosphorus in an Urban Shallow Lake

Keith Pilgrim[1] and Bill Bartodziej[2]
[1]Barr Engineering, Edina, Minnesota; [2]Ramsey-Washington Metro Watershed District, Little Canada, Minnesota

As lake managers we want to want to know with some level of certainty what the outcome may be with a given lake management action. At Kohlman Lake, Oakdale, Minnesota, an extensive and dense population of aquatic plants became established with increased lake clarity—the outcome of several management activities. In order to manage the outcome (plant growth) of

previous management activities, the Ramsey Washington Metro Watershed District agreed to conduct limited mechanical plant harvesting on a trial basis. Beyond aesthetics, which is often the goal of harvesting, there are several questions that this current study intended to address: 1) How much phosphorus is removed from the lake system with harvesting—can we view harvesting as a phosphorus BMP similar to watershed controls and in-lake treatments? 2) Is there an effect on in-lake phosphorus concentrations and other water quality parameters with limited harvesting, 3) For this particular harvesting program, was there an effect on aquatic plant growth? 4) What is the contribution of aquatic plants to the overall phosphorus mass balance for Kohlman Lake. The results of this study will be discussed, including some the field and laboratory measurement methods and the modeling approach employed to analyze the data and develop an overall understanding of the Kohlman Lake system.

Part III: Bridging the Gap between Public Expectations and Realistic Management Solutions of Shallow Minnesota Lakes

Lyndsey Provos and Bill Bartoziej
Ramsey-Washington Metro Watershed District, Little Canada, Minnesota

The Ramsey-Washington Metro Watershed District (RWMWD) is located in Eastern Ramsey County and Western Washington County, Minnesota encompassing 65 square miles, 12 cities, and 20 lakes. RWMWD is charged with meeting the state water quality standards for Minnesota surface water. After intensive lake and watershed management, Lake Kohlman was moved from a turbid to a clear water state. Although there was a significant improvement in water quality, the increase in aquatic plant and filamentous algal growth caused public conflict. It seemed that water quality became secondary. There was disconnect between residents' expectations and the reality of how healthy shallow lakes function. Water skiing, swimming, sandy bottoms with little aquatic plant cover do not mesh well with Lake Kohlman in a clear water state. We chose to create a video as an educational tool to help communicate our message. In the video, we have local experts explain basic shallow lake ecology, clear water and turbid states, the difference between deep and shallow lakes, and how management must balance realistic lake use with preserving lake health. We have a local lakeshore owner tell her story. We have incorporated interesting animation and underwater and drone shots to help tell the story. We will show the video during the presentation and discuss how this message has been received by the public.

Floating Wetlands for Bulkhead Impact Mitigation in Urban Lakes

Rob Zisette
Herrera Environmental Consultants, Seattle, Washington

Bulkheads and other hardened shorelines in urban lakes can protect property from erosion, but the increased wave reflection caused by their presence erodes lake sediment, resulting in offshore sediment drift and a loss of emergent plant habitat. Sediment suspension and drift to deeper waters can impact lake water quality by increasing internal phosphorus loading. Loss of emergent vegetation can impact fish and wildlife, including endangered Chinook salmon. Green shoreline initiatives by Seattle and others promote removal of bulkheads to create natural beaches costing approximately $600 per linear foot. Floating wetlands are an effective alternative to bulkhead removal at about half the cost. This presentation will summarize bulkhead impacts, compare commercially-available floating wetland systems, describe their potential water quality and habitat benefits, and present alternative designs for the installation of floating wetlands along bulkheads in urban lakes.

Session B6: Innovative Modeling (WMAO)

1:30 pm – 3:00 pm | South Meeting Room 233

The Role of Water Management and Climate Change Uncertainty: A Case Study in the Maumee River Watershed

Haley Kujawa
The Ohio State University, Chesapeake, Virginia

Planning resilient water management in the face of climate change is a problem everywhere. A common approach of incorporating climate change analysis into watershed management consists of using a single hydrological model driven by temperature and precipitation data from an ensemble of general circulation models (GCMs). While this method may capture the range of future climate predictions, it does not account for bias introduced from the hydrological model. This study highlights the uncertainties associated with independently set-up process-based models used in climate change analysis. This work was done on the Maumee River Watershed, which is a priority for reducing Lake Erie's harmful algal blooms. Five Soil and Water Assessment Tool (SWAT) configurations for the Maumee watershed were set-up and calibrated by independent research groups who were allowed freedom to retain differences in model structure, inputs, management, and parameterizations. All models performed well when compared with observational data of discharge and nutrient loads. We then drove these SWAT models with daily temperature and precipitation predictions from an ensemble of six GCMs. The results suggest that the models generally agree on changes in discharge, and yet future water quality shows a large range of uncertainty and cannot be fully explained by the changes in precipitation and discharge. While numerous studies have used a single SWAT model with an ensemble of GCMs for future water quality prediction in the Maumee River watershed, this study highlights the importance of uncertainty derived from the SWAT model.

Assessing Uncertainty in Hydrological Models Within the Maumee River Watershed: The Role of Parameters and Farm Management Assumptions

Anna Apostel
The Ohio State University, Columbus, Ohio

The need for water quality models has been at the forefront of recent discussions about meeting Lake Erie targets for nutrient loading. Models can expand the predictive capacity for a watershed, especially where there is limited monitoring

data, and therefore can be a powerful tool. However, a key limitation for interpreting model results is that some models, called deterministic models, produce one prediction without placing it within the context of uncertainty bounds. This is the case with the Soil and Water Assessment Tool (SWAT). Despite successful use of SWAT in several policy-relevant projects in the Maumee River watershed, including projects comparing outputs from five separate SWAT models, stakeholders are asking modelers to put their results in the context of uncertainty or confidence in those results. This project aims to assess the role of two separate drivers of uncertainty: parameter uncertainty and farm management assumptions. The SWAT model for the Maumee watershed has been updated to include hydrologic response unit (HRU) discretization focused on near field level delineation, allowing for direct incorporation of spatially-realistic management practices. We identified 1) a suite of parameter sets representing a range plausible values for commonly calibrated model parameters; and 2) a suite of farm management scenarios based on common model representations of real world practices and historical management trends. The model was run over each unique combination of parameter and management scenarios and model output variance was measured as impacted by variation in parameters and management representations. This variance in model output at several scales allows us to begin to quantify the magnitude and characterize the source of potential uncertainty. This provides valuable insight into where our models can be improved and how results should best be interpreted for management and policy development the region.

Multiple Models Assess Options for Reaching Lake Erie's Phosphorus Reduction Targets

Margaret Kalcic
Ohio State University, Columbus, Ohio

In 2016 the United States and Canada formally agreed to target reductions of phosphorus inputs to Lake Erie with the intention of alleviating the lake's eutrophication. This included a 40% reduction from 2008 levels of March–July total phosphorus and dissolved reactive phosphorus loading from the Maumee River watershed. A key remaining question is what can be done in Lake Erie watersheds to meet these targets. Specifically, what land management options and rates of implementation will be needed to reach this 40% reduction? Here we will highlight results from an interdisciplinary research collaboration in which a stakeholder advisory group assisted in identifying feasible and desirable conservation options for the watershed, which were in turn tested in multiple models of the Maumee watershed. We find that multiple pathways (suites of conservation practices) move towards targets, with the potential for mixing/matching a variety of practices given producer preferences. Models agreed that widespread adoption would be needed, and the targets for total phosphorus would be more readily attainable than those for dissolved phosphorus.

Power of Volunteer Water Quality Data in Examining Regional Water Quality in SW Ohio, 2017

Michael Miller
Rivers Unlimited, Green Umbrella Watershed Group, Cincinnati, Ohio

Organized in the Watershed Action Group of our regional sustainability organization, Green Umbrella, we have developed 4 programs using OEPA Level 2 methodologies to evaluate impacts of effluent and eutrophicational nutrients on surface waters of Greater Cincinnati. We monitor 220 sites monthly at the same time on the same date by 4 groups (Lower Great Miami River Water Quality Program of Rivers Unlimited, lower Little Miami River Saturday Stream Snapshot of Greenacres Foundation, Mill Creek watershed with Mill Creek Alliance, and Butler County Stream Team supported by Miami University Environmental Studies Program and Butler County Stormwater District. We monitor Total Phosphorus, Nitrate-N, Conductivity, Turbidity, pH, *E. coli* and total coliform density, *in vivo* chlorophyll, and optical whiteners. Using OEPA water quality criteria we generate a Water Quality Rank for each parameter on a scale of 1 (poor) to 5 (good) averaged over 6 parameters in common we can talk about the quality of each site the averages the ranks for 9 dates × 6 parameters = 54 determinations per year. With 5–10 sites in the mainstem our rivers are ranked from 220–540 determinations. In 2017, the Whitewater River was the cleanest, the Little Miami second, the Great Miami third, and the Mill Creek best in the upper 7 miles and worst in the lower 18 miles. The pattern is related to land use and effluent loading primarily with TP, Nitrate, Conductivity and *E. coli* being the most revealing. Great Miami is loaded with N-rich nutrients from agriculture and effluent improving downriver. The Little Miami is challenged by WWTP effluent at numerous sites along our reach. The Mill Creek is degraded in lower river by effluent, CSO & SSO runoff with pulsed flows. The Whitewater River has excellent water quality, although it is receiving some violations recently.

Session B7: Contaminants (WMAO)

1:30 pm – 3:00 pm | South Meeting Room 236

Decentralized Treatment of Sewage Flows

Rakesh Govind
University of Cincinnati, Cincinnati, Ohio

The world is running out of fresh water, and current methods of treating wastewater at centralized treatment plants and disposing the treated water into creeks/rivers results in sending the used freshwater, generally obtained from ground water, into the ocean, where it becomes salt water. Decentralized treatment promotes local wastewater treatment with the treated water being used for irrigation, which returns the water back to the ground. In this paper, methods for decentralized treatment of sewage will be presented.

Toxicity Impact Assessment of PFOS and PFOA

Joshua Glass
Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio

Per- and Polyfluoroalkyl Substances (PFAS), a class of toxic and persistent emerging contaminants, have led to rising concerns about health effects of drinking water contaminated by certain PFASs. The problem extends from groundwater near sites impacted by the repeated use of firefighting aqueous film-forming foams (AFFF) and surface water sources. Numerous remediation efforts have been proposed for contaminated sites; however, little is known about the toxicological effects of the contamination. Data was collected through a comprehensive literature review of research that analyzed PFAS effective doses for various adverse health symptoms. Using methodology and calculations derived from the USEtox tool, the data collected was analyzed to obtain comparable toxic units (CTU) for PFOA and PFOS using two scenarios. The first scenario assumed that the full concentration of contaminates was ingested by the exposed populations and the second scenario calculated the intake assuming the contamination infiltrated the Great Miami Buried Valley Aquifer contaminating the water supply to the city of Dayton, Ohio. CTUs values were calculated for both scenarios using varying concentrations of PFAS contamination.

PFOS Fate and Transport Modeling Using Numeric and Analytic Models

Ramoane Jordan
Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio

Per/polyfluoroalkyl substances (PFASs), a group of emerging water contaminants, have been widely used in numerous industrial and commercial applications since the 1950s. Due to rising concerns about health effects related to certain PFASs, a particular application to note is the use of PFOS in aqueous film-forming foams (AFFF). Historical reports have shown a correlation between higher concentrations of PFASs and sites impacted by the repeated use of AFFF through fire training and performance testing, thus prompting a need for quantifying contamination. Numeric and analytic modeling tools were utilized, with distribution properties of PFOS attained from literature and physiochemical properties of the subsurface, to simulate PFOS transport under a fire training area. Model results provided information about plume dispersion, retardation, and transformation. The information from this modeling exercise provide information needed for remediation decision-making and risk analysis.

The Impact, Fate, and Viability of *Bacillus globigii* Spores and MS2 Bacteriophage Injected into Activated Sludge

Willie Harper
Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio

Introduction of biocontaminants into the water cycle may pose a threat to public safety. Biocontaminated wastewater could result from accidental or intentional contamination incidents, including wash down water in the aftermath of an attack, as well as hospital waste. The impacts, fate, and viability of these biocontaminants within and after biological treatment processes are key concerns for addressing disposal of biocontaminated wastewaters. This work used two biocontaminants, *B. globigii*, a surrogate for *B. anthracis*, and MS2 bacteriophage, a common surrogate for noroviruses. *B. globigii* spores and MS2 bacteriophage did not cause statistically significant differences in the maximum rate of O_2 uptake, and they did not discernably alter the shape of the respirometric profiles over a wide range of initial concentrations. COD and nitrogen removal were not negatively impacted by *B. globigii* spores or MS2. However, when *B. globigii* spores were added without washing off the ethanol, the relative cumulative O_2 uptake was significantly higher in two of four experiments at a spore concentration of 2×10^5 CFU/mL. Overall, these results showed that *B. globigii* spores and MS2 bacteriophage do not interfere with microbial respiration; however, ethanol caused initial inhibition. This result could be significant if biocontaminants are introduced into a treatment plant with an organic co-solvent. Typically, biocontaminants were present both in the bulk and in the solid phase. Plating and microscopic analysis of effluent samples indicated that both MS2 and *B. globigii* spores remained viable after exposure to activated sludge in batch experiments. When *B. globigii* spores were injected into the pilot plant system at 3.7×10^5 cfu/ml, samples collected over 7 weeks all showed the presence of germinated *B. globigii* cells regardless of collection location (*i.e.*, primary effluent, activated sludge at different locations, and secondary effluent). The germination percentage (*i.e.*, the number of germinated spores relative to the total number of spores in a given sample) was between 1–25% across all samples and generally increased with time, suggesting the formation of new, biochemically active daughter cells.

Session C1: Large Data Sets and Long-Term Monitoring

3:30 pm – 4:40 pm | West Meeting Rooms 260–261

The Use and Limitations of Large Data Sets in Evaluating the Health of Percid Stocks in Select New York Waters 1991–2016

★ **J.R. Hulbert[1], D.S. Stich[1], and S.M. Wells[2]**
[1]Biology Department, State University of New York College at Oneonta, Oneonta, New York; [2]New York State Department of Environmental Conservation, Region 4 Fisheries, Stamford, New York

Walleye (*Sander vitreus*) and yellow perch (*Perca flavescens*) are a common cool-water predator-prey combination found in lakes and reservoirs throughout North America and are actively managed to support fisheries throughout New York State (NYS). Fish wellbeing in most fish populations is strongly correlated to growth rates, change in body composition, condition, and in many examples relative weight (Wr) may be a more robust predictor of fecundity than that of growth. The ability to quantify and model the relationship between fish weight and length is essential for effective fisheries management. However, estimation of Wr is often difficult in data-limited populations. We used Bayesian hierarchical methods with data from 1991–2016 to fit Wr models to weight-length data for walleye and yellow perch collected from various waters in southeastern NYS. The model

also provides regional estimates of drivers of Wr. Walleye relative weights (Wr) were similar between waterbodies, but relative weights (Wr) of yellow perch caught was notably smaller in Canadarago Lake than in other lakes. On a regional scale, annual Wr for Walleye increased was 0.79 to 1.04, and Wr for yellow perch decreased and was 0.73 to 0.84. Future work on Percids in this region will investigate number of factors that influence weight-length relationships.

Water Quality in Lake Mead During Extended Drought: Why Has There Been So Little Change?

Todd Tietjen
Southern Nevada Water Authority, Las Vegas, Nevada

Lake Mead has been influenced by the drought occurring throughout the Colorado River Basin since the year 2000. While inflows have varied over this period the overall direction has been down resulting in significant decreases in the lake surface elevation and water storage. Despite this ongoing decrease in water the water quality in Lake Mead has been remarkably stable. Thermal stratification patterns have remained consistent with complete mixing of the water column every 2 years and partial mixing every year. Specific conductance values have been influenced by basin wide shifts in salinity more than drought over this period. Nutrient concentrations have remained within a fairly narrow range owing to the stability of nutrients entering the lake through the Colorado River and continued high level of wastewater treatment in the Las Vegas Valley. These stable nutrient concentrations have produced stable chlorophyll *a* concentrations and high Secchi disk transparency. While the active management of nutrient loading by the Las Vegas Wash has played a significant role in maintaining high water quality, the short retention time, rapid flushing, of the reservoir is likely to have added to the stability of the system.

Kentucky Lake (USA) is Undergoing a "Change of State": 'Tipping Points' in Water Quality May Require New Approaches for Lake Management

Susan Hendricks[1,2], David White[1,2], Bommanna Loganathan[3], and Kate He[2]
[1]Hancock Biological Station, Murray State University, Murray, Kentucky; [3]Department of Biological Sciences, Murray State University, Murray, Kentucky; [2]Department of Chemistry, Murray State University, Murray, Kentucky

Kentucky Lake (Tennessee River) is the largest man-made reservoir east of the Mississippi River, USA. Trend analyses of several physicochemical and biological variables in the 30-year long-term database reveal important changes and indicate that 'tipping points' may have been reached in lake chemistry and its watershed that have enabled successful species invasions (*e.g.*, zebra mussels, Asian carp). Significant multidecadal increases were found for water temperature, total calcium carbonate alkalinity, calcium ion, chloride ion, silicon dioxide, Secchi depth, and light penetration. Multidecadal decreases were found for silicon dioxide, soluble reactive phosphate, turbidity, sulfate, and primary production. Variables that remained relative constant include chlorophyll *a*, total nitrogen, and total phosphorus. The new source of calcium is likely from increased use of road deicing brine (calcium chloride) over the past decade and from runoff and precipitation containing higher alkalinities. Between 2012 and 2017, calcium levels exceeded the 21–23 mg/l threshold for zebra mussels thus enabling their permanent establishment in the lake by 2017. Long-term effects of invasive species on the plankton population still are to be determined, but the three-decade decrease in primary production is unmistakable even though chlorophyll *a* has remained fairly constant from year to year. Water temperature changes are likely due to climate change while increases or decreases in other variables are due to increasing or decreasing anthropogenic pollutants and land-use change within the watershed.

Session C2: Autonomous Sampling and Automated Techniques

3:30 pm – 4:40 pm | West Meeting Room 262

Semi-Automated Method for Detecting and Counting Cells of Cyanobacterial Colonies and Filaments

Frances Buerkens[1], Peggy Lehman[2], and Harry Nelson[1]
[1]Fluid Imaging Technologies, Scarborough, Maine; [2]California Department of Fish & Wildlife, Stockton, California

Harmful algae blooms are increasing in frequency and intensity. Public safety and conservation agencies demand a replicable and scalable method to rapidly detect and enumerate cells comprising cyanobacterial colonies and filaments. The FlowCam is a proven technology that identifies taxa to the genus level and provides an estimate of the abundance of individual cells. It combines digital imaging, flow cytometry, and microscopy to calculate the dimensions, biovolume and abundance of cells. The FlowCam Cyano leverages recent technological developments – a 633 nm laser – enabling the instrument to distinguish cyanobacteria from other algae in a water sample. The abundance of cells within colonies and filaments are counted using a simple Excel based formula, enabling monitoring agencies and researchers to rapidly enumerate cells in large sample volumes. The FlowCam system facilitates an accurate measurement of cell abundance for large folded colonies because the colonies flatten within the unique flow cell chamber. Here we present an overview of the technology along with HAB field data from freshwater systems that affect drinking water and recreational lakes across North America.

Innovations in Water Quality Sonde Integration and Cloud-Based Data Automation

Eric Robinson
In-Situ Inc., Fort Collins, Colorado

This workshop provides an overview of the newest water quality sondes and sensors from In-Situ, designed for ease-of-integration with systems on telemetry. The workshop will also discuss automating connections between In-Situ's HydroVu cloud data services and your environmental database via an API, with real world examples. Save time and eliminate data entry errors by learning how to automatically import your In-Situ data into your database.

Building a Lake-Scale Smart-Sensor Network for Intelligent Environmental Monitoring

Michael R. Kelly, Eli M. Dow, Vincent W. Moriarty, John Ma, and Harry R. Kolar
IBM Research, Yorktown Heights, New York

Lake George is a freshwater oligotrophic lake in upstate New York. The Jefferson Project at Lake George, a partnership between Rensselaer Polytechnic Institute, IBM, and The FUND for Lake George is studying the lake through a new observational sensor and intelligent computing network. This advanced cyberphysical system augments ongoing traditional scientific experimentation and data collection. Data from multisensor platforms in and around the lake are assimilated by coupled computer models for weather, runoff, circulation, and the food web, and also provide validation for these models. A better understanding of these processes within the lake and surrounding watershed is enabling more informed decision making and long-term preservation of this valuable resource.

The Smart-Sensor Network design and implementation will be presented. Advanced environmental monitoring functionality is made possible by distributed Internet of Things (IoT) computing nodes and bidirectional communications within the sensor network. Manual, automated, and adaptive monitoring capabilities of the network operation are described, and examples of data collected through this advanced network will be shown.

Session C3: Ohio Lakes

3:30 pm – 4:40 pm | West Meeting Room 260–263

Nutrient Issues Affecting Ohio's Inland Lakes: Evolution of Program and Lessons Learned

Rick Wilson[1], Shannon Brattebo[2], Harry Gibbons[3], and Kevin Kratt[4]
[1]Ohio EPA, Columbus, Ohio; [2]Tetra Tech, Inc., Spokane, Washington; [3]Tetra Tech, Inc., Seattle, Washington; [4]Tetra Tech, Inc., Cleveland, Ohio

Over the past several years, the State of Ohio has taken steps to advance the State's nutrient reduction efforts. Some of these efforts are specifically focused on reducing the occurrence and impact of harmful algal blooms in inland lakes and lakes that are sources of drinking water. Ohio EPA programmatic planning continues to evolve regarding strategic collection and use of data and with engagement of appropriate watershed stakeholders. Tetra Tech provided Ohio EPA with recommendations on how to best develop a more robust lake management planning process which includes collaboration among agency staff to prioritize lakes and training of personnel on lake monitoring and management. A summary of these recommendations as they relate to Ohio's efforts to restore and protect inland lakes from nutrient related impairments will be provided. In addition, examples and lessons-learned from lake management programs at Grand Lake St. Marys (GLSM), Buckeye Lake, and Kiser Lake will be discussed. GLSM, Buckeye Lake, and Kiser Lake are large, shallow inland lakes that are heavily impaired due to excess nutrients from both the watershed and internal loading. GLSM is also a drinking water supply. Implementation of a variety of lake management strategies by the State, partner organizations, and land owners have led to watershed nutrient load reductions and measurable water quality improvement at both GLSM and Buckeye Lake.

Tappan Lake Nutrient Reduction Initiative: An Interdisciplinary Water Research and Collaboration Initiative Among Various Organizations to Eliminate HABs From the Tappan Lake Water

Fernanda Craig[1] and Josh Britton[2]
[1]Muskingum Watershed Conservancy District, New Philadelphia, Ohio; [2]Harrison Soil & Water Conservation District, Cadiz, Ohio

In response to persistent, low-level concentrations of microcystin in Tappan Lake water over the past few years, the Tappan Lake Nutrient Reduction Initiative (TLNRI) was designed to eliminate the presence of harmful algal blooms, and their resultant water-borne toxins, in Tappan Lake water, within the next decade. The TLNRI relies on a partnership of multiple organizations, all of which support the goal of achieving long-term, sustainable improvements in Tappan Lake water quality, through administrative, technical and/or financial support. The TLNRI currently envisions three steps toward achieving its goal; The three phases include a comprehensive study of existing water quality data for the Tappan Lake watershed, and the identification of the data gaps, the collection of data (to fill identified data gaps) resulting in enough technical information to support a confident evaluation and selection of remedial actions for the watershed, and the implementation of a remedial action plan for the watershed, including education programs. This presentation will highlight this interdisciplinary water research and collaboration among organizations, and the participation of all the scientists, who come with a variety of expertise in water quality and/or socio-economic activities in the watershed. The presentation will explore the current accomplishments and progress achieved through this initiative, as well as future milestones and goals.

Session C4: Algal Toxins

3:30 pm – 4:40 pm | West Meeting Room 264

Ecological Role of Microcystin: Evidence from a Field Study

Aabir Banerji, Mark Bagley, Jody Shoemaker, Dan Tettenhorst, and Jorge SantoDomingo
US Environmental Protection Agency, Cincinnati, Ohio

Microcystis aeruginosa is a common constituent of freshwater harmful algal blooms and can produce microcystin, a potentially lethal hepatotoxin. Understanding drivers of change in microcystin concentration may be beneficial in establishing best practices. Microcystin is hypothesized to function at least secondarily as both an allelochemical and an anti-predator defense. If microcystin is effective in these ecological roles, then relative abundances of certain predators and competitors of *Microcystis* should decrease with increasing microcystin concentration. In contrast, relative abundances of taxa that utilize (degrade) microcystin should increase with elevated microcystin

concentrations. We tested these hypotheses by investigating associations among microcystin, *Microcystis*, and the overall plankton community using water samples collected from a multipurpose reservoir in southeastern Ohio. We measured microcystin concentrations via mass spectrometry and profiled the plankton community via 16S and 18S DNA metabarcoding analyses. We used random forest regression analyses to determine if variation in microcystin concentration and *Microcystis* relative abundance was associated with changes in the planktonic community. We found that 74% of total variance in microcystin concentration and 89% total variance in *Microcystis* relative abundance could be explained by changes in the planktonic community. However, we found no evidence for antagonistic interactions between microcystin and ecologically relevant taxa, suggesting that microcystin performs other roles. Despite numerical dominance of arthropod DNA among eukaryotic sequences, arthropods had negligible explanatory power, whereas microbes such as protists and heterotrophic bacteria were tightly linked to microcystin levels. These microbes may warrant further attention as potential indicators or remediators of microcystin.

Management of Cyanobacteria and Their Associated Cyanotoxins and Taste and Odor Compounds

Fred S. Lubnow
Princeton Hydro, LLC, Exton, Pennsylvania

Cyanobacteria, also known as blue-green algae, are responsible for a large portion of the water quality problems experienced in both the surface waters of potable water supplies and well as recreational waterbodies. In addition to generating nuisance and aesthetically displeasing blooms and surface scums, many cyanobacteria produce cyanotoxins, which pose potential health problems for humans, pets and livestock. In addition, cyanobacteria can also produce taste and odor (T&O) compounds such as geosmin and methyl-isoborneol (MIB); while these compounds do not pose health hazards they can produce unpleasant taste and odors in potable water supplies.

This presentation will briefly review the ecology of cyanobacteria, which will include a description of conditions that typically result in nuisance blooms as well as how they are adapted to be very successful in freshwater ecosystems. However, the focus of the presentation will be to review protocol and actions associated with measuring and managing the production of cyanotoxins and T&O compounds in potable and recreational waterbodies. The management portion will include both proactive and reactive measures to avoid and minimize the generation of such nuisance compounds, respectively. Finally, the presentation will provide recommendations on how to move forward with the implementation of a Cyanobacteria Management Plan using the PARE program.

Assessing the Role of Vertical Mixing in Modulating Cyanobacteria Blooms in Shallow Reservoirs

Daniel R. Obenour[1], Yue Han[1], Jeremy Smithheart[1], Robyn Smyth[2], and Tarek N. Aziz[1]
[1]North Carolina State University, Raleigh, North Carolina; [2]Bard College, Annandale-on-Hudson, New York

Transport phenomena are important drivers of water quality in aquatic systems. In lakes and reservoirs, vertical mixing through turbulent diffusion is expected to influence the dominance of problematic cyanobacteria relative to other algal taxa. In this study, a systematic approach for calibrating and validating a vertical mixing model is presented, followed by a statistical analysis of how vertical mixing, nutrients, and other environmental factors influence formation of cyanobacteria blooms. The mixing model was originally developed for Jordan Lake, a eutrophic reservoir in North Carolina, and model outputs compare favorably with thermistor chain records and *in situ* diffusion estimates obtained from a temperature micro-profiler and dye tests. The model was used to determine major meteorological controls on vertical diffusion, water temperature, and water column stability, as well as the potential influence of mechanical surface-layer circulators that were installed in portions of the study area. The model was also applied to characterize vertical mixing in two other North Carolina reservoirs with unique geometries, depths, and artificial mixing applications. Using simulated diffusion rates and stability metrics for all three reservoirs, coupled with multiple years of nutrient and phytoplankton community sampling data, a hierarchical multiple linear regression was developed to assess key relationships influencing cyanobacteria dominance and total biomass. Our results indicate the importance of vertical mixing relative to other factors influencing cyanobacteria proliferation. Using the integrated models, we assess the potential efficacy of artificial mixing applications to mitigate these blooms.

Session C5: Hypolimnetic Withdrawal

3:30 pm – 4:40 pm | South Meeting Rooms 237–238

Revisit of the Lake Restoration Technique Hypolimnetic Withdrawal

Gertrud K. Nürnberg
Freshwater Research, Baysville, Ontario, Canada

Hypolimnetic withdrawal is an established lake restoration technique in Europe that has been underused in lakes and reservoirs of North America. Its operating and maintenance efforts are low because it is based on the damming of surface outflow and discharging of bottom water, thus removing unwanted substances from the hypolimnion. Since the first application in 1954, hypolimnetic withdrawal has been studied in more than 50 lakes including the deep-water withdrawal in large reservoirs, in small man-made ponds, and in remote lakes. Current applications include an urban impoundment in Michigan to treat cyanobacteria blooms, a Californian canyon reservoir, and a Canadian agricultural lake. New applications take special consideration of treating the withdrawal water and

involve Swedish Bornsjön, the back-up drinking water system for Stockholm Vatten, and a Finnish lake, Kymijärvi. The comparison of water quality variables before and during treatment indicates decreasing eutrophication in most, but not all, treated lakes. The current study investigates the working principle of hypolimnetic withdrawal and strives to separate treatment effect from concomitant influences, including external load reduction and climate effects. Potential negative effects of hypolimnetic withdrawal due to influences on the thermal structure of a lake are explored. The importance of treating the withdrawal water is discussed.

Battling High Internal Phosphorus Loads with Hypolimnetic Withdrawal and a Unique Water Treatment Plant in Lake Bornsjön, Sweden

Johanna Ansker
Stockholm Water and Waste, Stockholm, Sweden

The lake Bornsjön (6.6 km^2) serves as a drinking water backup for the City of Stockholm, Sweden. It has been suffering from hypoxia and internal phosphorus (P) loading for several decades. To improve hypolimnetic water quality, the restoration treatment of hypolimnetic withdrawal is being implemented. The withdrawn water started to be treated in a special water treatment plant in 2017. This treatment plant is a unique treatment facility, as it combines well-known water purification techniques with lake restoration knowledge. The treatment plant design is to both, prepare water for drinking water and to treat P-rich water from the hypolimnion. For two months/year the plant pumps water through a 4.5 km long pipe from the deepest basin of Bornsjön. The P-rich water is treated with aluminium sulphate, passes through four flocculation chambers, and is left to settle in lamella sedimentation basins followed by rapid sand filtration. The waters total P has then been reduced from 490 µg/l to 10 µg/l and is led back into the hypolimnion in a different basin, where the oxygen-rich water prevents hypoxia. During the initial adjustment period in 2017 the withdrawal flow rate averaged 300 m^3/h and P concentration ranged 330-840 µg/l. Average P removal was 95% and peaked at 97.5 %. During the one-month treatment period, almost 170 kg phosphorus was removed from Bornsjön. It is estimated that the plant can run at a rate of 500 m^3/h so that 300–400 kg P can be removed in the 2018 treatment period (late August – late October).

Session C6: Innovative Watershed Planning (WMAO)

3:30 pm – 4:40 pm | South Meeting Room 233

The Art of Building Nonpoint Source Implementation-Strategic (NPS-IS) Plans for Successful Project Funding

Deanna Bobak
Civil & Environmental Consultants, Inc., Toledo, Ohio

In order to receive nonpoint source funding (Section 319) from state and federal agencies, projects must be included in an approved nine-element plan. Of the more than 1,500 watershed assessment units in Ohio, only a small percentage have approved Nonpoint Source-Implementation Strategic (NPS-IS) plans. In general, NPS-IS plan development includes the identification of causes and sources of impairment, the delineation of critical areas in which project implementation is most likely to address impairment and the inclusion of projects that will move a watershed toward impairment delisting. Authored by numerous entities (watershed champions), these plans use a common template from Ohio EPA, but vary in the approach taken during development. Strategic planning and key stakeholder involvement in NPS-IS plan development has yielded over $300,000 in project funding across several watershed assessment units in the Lower Maumee watershed in just under one year, with additional projects earmarked for funding. This presentation will demonstrate a path to project funding by incorporating a successful plan development approach to leverage grant dollars.

Big Data's Impact on Water Resources Management

John Menninger
Stantec Consulting Services Inc., Cincinnati, Ohio

Big data. Internet of things. Ubiquitous sensing. Cloud storage and computing. Artificial intelligence. These buzzwords typically associated with the high tech industry and Silicon Valley are making their way into water resources management and will transform how the industry operates.

The speaker will present recent advances in technology likely to impact the industry, provide case studies on the use of big data applications on recent projects and identify opportunities for water resources managers to improve their organization. Examples will include use of sensor networks and machine learning for real-time water quality monitoring and alarms; application of multi-variate statistical analyses with Monte Carlo simulations to better understand flood risk; and the implications of cloud computing on the performance of hydrologic, hydraulic and water quality models.

Using Web Based Interactive Tools for Better Watershed Management and Resource Protection

David Rutter
Ohio Kentucky Indiana Regional Council of Governments, Cincinnati, Ohio

The Ohio, Kentucky, Indiana Regional Council of Governments has leveraged funds from both state and federal sources to develop web based tools and resources that improve environmental considerations in planning efforts. These tools are the Environmental Viewer, My Community's Water, and www.treesandstormwater.org.

The Environmental Viewer was developed to assist in the environmental consultation process for transportation planning but has also become a powerful tool for local communities to quickly identify potential impacts of proposed projects within their jurisdiction on environmental resources. These resources include high quality streams, protected lands, wetlands, endangered species, aquifers, prime farmland, agricultural districts, and tree canopy.

My Community's Water was developed for the four Ohio counties in the OKI region. This on-line tool is targeted to both local officials as well as the general public. The user, by selecting a community can explore all of the water resources within the jurisdictional boundaries including watersheds, population distribution by watershed, impervious surfaces, number of stream miles, and soils.

The Trees and Stormwater Guide at www.treesandstormwater.org was developed in partnership with the US Forest Service, Davey Resource Group, Centerline Strategy, LLC, and the National Association of Regional Councils. This tool provides a wealth of information to aid local decision makers to incorporate trees into their stormwater management.

Each of these tools was developed for a specific purpose but the choice to make them available to the general public on the website provides local officials, planners, and citizens the opportunity to use them in ways that support their own work and interests.

Session C7: Nutrient Loading (WMAO)

3:30 pm – 4:40 pm | South Meeting Room 236

Water Quality Impacts from Stacked Agricultural Conservation Practices

Elizabeth Callow
The Ohio State University, Columbus, Ohio

Water quality issues resulting from non-point source pollution have negatively impacted many waterbodies around the State of Ohio and the Midwestern United States. In agricultural settings, these water quality issues have required thoughtful innovation to retain nutrients on the field for use by crops, at the edge-of-field, or in the agricultural ditch. Conservation practices are often utilized to help retain nutrients at their site of placement in both urban and agricultural landscapes. Stacking of best management practices is being investigated to evaluate the efficacy of the individual practice as well as the benefit of placing practices in series. In this study, the practices which are being evaluated include cover crop application, a two-stage ditch, and grassed surface furrow ditches. The cover crop is applied to the field which drains to the surface furrow ditches and then empties into the two-stage ditch. Each of these practices are monitored using ISCO samplers, which collect base flow and event driven water samples. Preliminary data is currently being analyzed to determine the nutrient load impacts of each practice individually, as well as the added benefit of stacking the suite of practices.

Agricultural Best Management Practices Impact Soil Health and Phosphorus Loadings in Lake Erie's Maumee River Watershed

Grey Evenson
The Ohio State University, Columbus, Ohio

Agricultural best management actions (BMPs) have the potential to decrease phosphorus loadings from Lake Erie's Maumee River watershed and thereby reduce the occurrence of harmful algal blooms and hypoxia. Preceding work has applied the Soil and Water Assessment Tool (SWAT) model to evaluate the effectiveness of agricultural BMPs in reducing the watershed's phosphorus loadings. However, evaluation of a subset of BMPs – specifically, no-till and cover crop rotations – has been hindered by the model's limited capacity to represent the potentially beneficial impact of these actions on soil health and water holding capacity. First we modified the SWAT model source code to facilitate representation of increased soil water holding capacity as affected by soil health BMPs. Then we modeled the effectiveness of these BMPs and compared to scenarios prior to source code changes. Preliminary results indicate that a 1% increase in soil organic matter, as impacted by no-till and cover crop rotations, may significantly decrease phosphorus loadings to the Lake – though model predictions varied as we assessed differing literature-based descriptions of the relationship between soil organic matter and water holding capacity. Our evaluation of no-till and cover crop rotations as impacting soil health will further efforts to evaluate the effectiveness of these actions as part of a larger suite of agricultural BMPs in addressing Lake Erie harmful algal blooms and hypoxia.

Within-River Phosphorus Retention in Western Lake Erie Tributaries: 1900–2018

Christopher Spiese
Ohio Northern University, Ada, Ohio

Retention of total and dissolved phosphorus (TP and DRP, respectively) within the river channel is a potential sink for these nutrients under low flow regimes and a possible additional source during high flow. P can be retained in the channel in multiple forms, including biological, chemical, and physical sequestration. A portion of this retained P can contribute to "legacy" loads, as retention can change over large time scales. This study examines the magnitude of within-river P retention over time. Using chemical data, conservative and non-conservative models for P concentrations are created and retention determined by the difference. Historical flow data from USGS gage stations across the basin provide a longer-term and more regional view of retention.

Poster Session

5:45 pm – 7:00 pm | Grand Ballroom B

2017-2018 Study of *Phragmites* Management Effects at The Esplanade

Brea Arvidson
SŌLitude Lake Management, Shrewsbury, Massachusetts

As a primary greenspace of Boston, Massachusetts, The Esplanade is a public park that supports thousands of visitors, programs, events, and wildlife. The park is relatively young, having been constructed in the 1930s, creating a prime environment for non-native species such as common reed *(Phragmites australis)* and false indigo *(Amorpha fruticosa)* despite park maintenance and native-based landscaping. During this study, we documented the short-term effects of multiple management techniques on *Phragmites* and established a foundation for future management at The Esplanade. Seven 600 ft^2 plots of contiguous *Phragmites*

growth were established for multiple management strategies: cutting-tarping (1), cutting (1), herbicide-surfactant pairings (4), and non-management/control (1). Two herbicides (active ingredients imazapyr and imazamox) were selected for four herbicide-surfactant plots, each paired with two different surfactants – a methylated seed oil (MSO) and Tactic. Monitoring for native and non-native plant species was performed before and after management, where multiple post-management monitoring sessions were completed to document regrowth or immediate changes in plant assemblages up to one year post-management. Through this study, we can determine appropriate site-specific management techniques for the Esplanade based on short-term management efficacy, site characteristics, and public relation.

Forecasting *Microcystis aeruginosa* Population Dynamics from Bacterioplankton DNA

Mark Bagley, Jorge Santo Domingo, Aabir Banerji, and Joel Allen
US Environmental Protection Agency, Cincinnati, Ohio

The ability to forecast harmful algal blooms (HABs) in freshwater lakes and rivers is becoming critical for management of drinking water treatment and recreational activities. In Harsha Lake, located in southwestern Ohio, *Microcystis aeruginosa* is believed to be the dominant cyanobacterium responsible for production of harmful cyanotoxins and therefore implicated in previous recreational public health advisories. We used random forest regression modeling to evaluate the ability of bacterioplankton community dynamics, as measured by 16S rRNA gene DNA metabarcoding, together with nutrients and other environmental factors (*e.g.*, water gauge data, wind, temperature, rainfall), to predict relative abundance of *Microcystis* at 4 different locations in this lake over varying timeframes. When dividing the 2015 bloom season into 4-day intervals, 81–84% of variation in *Microcystis* relative abundance could be explained from community and environmental data one to four intervals (~ 4–16 days) in advance. Of 6009 operational taxonomic units identified by DNA sequencing analyses, 69 were highly significant components of the models. Water gauge data (*i.e.*, lake inflow, outflow, and height) also were highly significant model features while, surprisingly, total nitrogen, nitrate, ammonia and total phosphorus concentrations were not. These data provide preliminary evidence that genetic monitoring combined with environmental data can help support management of HAB health risks.

The Cyanobacteria Monitoring Collaborative – An Evolving Approach to Cyanobacteria Monitoring

Shane Bradt[1], Linda Green[2], Hilary Snook[3], Jasper Hobbs[4], Betty Kreakie[5], Jeff Hollister[5], Bryan Milstead[5], and James Haney[1]
[1]University of New Hampshire, Durham, New Hampshire; [2]University of Rhode Island, Kingston, Rhode Island; [3]US Environmental Protection Agency, Region 1, Chelmsford, Massachusetts; [4]New England Interstate Water Pollution Control Commission, Lowell, Massachusetts; [5]US Environmental Protection Agency, Atlantic Ecology Division, Narragansett, Rhode Island;

Starting in 2013, the New England Cyanobacteria Monitoring Workgroup was created to collaboratively address issues related to cyanobacteria in lakes and rivers. The workgroup spent several years developing standardized monitoring methods which could be used across the region to address both short-term cyanobacteria bloom events and long-term monitoring of dynamic cyanobacteria populations. During the past three summers, over one hundred waterbodies across the region have been sampled for cyanobacteria utilizing these protocols and the data shared among workgroup participants.

In late 2016, the workgroup officially transitioned to the Cyanobacteria Monitoring Collaborative (CMC). The name change reflects the changing nature of the group, both in approach and scope. The CMC has put increasing effort into collaboration with the goal of furthering the understanding and monitoring of cyanobacteria populations and blooms. In addition, collaborators have grown to include people and organizations outside New England, now ranging from coast to coast in the United States with additional interest from abroad.

A newly redesigned website (https://cyanos.org) provides access to news on the monitoring programs and activities, allowing interested groups and individuals to discover, learn about, and collaborate with the CMC. The CMC's three monitoring programs (bloomWatch, cyanoScope and cyanoMonitoring) are described in detail on the website including links to the materials and methods necessary to participate. In addition to this new virtual presence, the CMC offers training using a mobile lab in New England and virtual and site trainings beyond the group's home region.

Applying Paleolimnological Techniques to Reservoirs: Challenges and Possibilities

Victoria L.S. Chraïbi
Tarleton State University, Stephenville, Texas

Paleolimnology provides useful long-term data sets and holistic perspectives of lakes that inform management. These analyses have been applied to reservoirs with mixed results. Riverine impoundments do not follow hydrological or sedimentation models similar to most natural lakes, creating obstacles for the application of paleolimnology. For example, fast sedimentation rates, dredging, and the young age of reservoirs pose issues for dating sediment and ensuring undisturbed core chronologies. However, it is worth developing modified techniques that account for the unique properties of reservoirs. There is the potential to synchronize paleolimnological studies with modern limnological monitoring in reservoirs in order to understand how reservoir-specific processes are reflected in longer-term records. Paleolimnological analysis of reservoirs is especially promising for arid regions such as Texas and the American southwest, where natural lakes do not exist from which to procure sediment cores. This will enable the application of paleolimnology to better inform long-term management for a suite of problems that face riverine impoundments, including changes in hydrology and biotic structure due to decreasing precipitation, changing seasonality, and human activities like impoundment, diversion, and irrigation.

Nutrient Management Challenges in Coeur d'Alene Lake, Idaho

Craig Cooper
Idaho Department of Environmental Quality, Coeur d'Alene, Idaho

Coeur d'Alene Lake is a primarily oligotrophic lake that is a critical economic and cultural resource for northern Idaho. The lake also holds over 75 million tons of metal contaminated sediments that result from historic mining practices and is part of the Bunker Hill Superfund action. The metal contaminants are managed in place via a lake management plan that seeks to sustain high levels of hypolimnetic oxygen in order to trap metals within the sediments and facilitate long term remediation and restoration. Oxygen levels in the lake are managed by limiting productivity via a nutrient management strategy. These actions also support managing overall lake water quality for beneficial use. Harmful algae blooms occur in nearby lakes and are also a potential challenge for Coeur d'Alene Lake. Trend analyses indicate that, except for lead, dissolved metals levels are declining in the lake. In contrast, trophic status is trending towards a more productive system. These factors increase the risk of metals remobilization from the sediments and pose a long-term nutrient and oxygen management challenge. Phosphorus loads are increasing in many of the Coeur d'Alene Basin's watersheds and are primarily non-point source. Potential drivers of these changes will be discussed within the context of the known and unknown factors, as well as nutrient management activities.

Effects of Flow Diversion on Water Quality in a Shallow Prairie Reservoir

John-Mark Davies[1], David Vandergucht[2], Clayton Williams[3], and Helen Baulch[4]
[1]Water Security Agency of Saskatchewan, Saskatoon, Saskatchewan, Canada; [2]Water Security Agency of Saskatchewan, Regina, Saskatchewan, Canada; [3]University of Vermont, Burlington, Vermont; [4]University of Saskatchewan, Saskatoon, Saskatchewan, Canada

Selecting the appropriate methods for managing lake and reservoir water quality for any given waterbody depends on the management goals, site characteristics, and available resources. Buffalo Pound Reservoir is an important waterbody because it serves as the source water for over a quarter of the population in Saskatchewan, Canada. It is a shallow (mean depth 3 m), narrow (approximately 1 km) and long (approximately 30 km) reservoir in the Qu'Appelle Valley. The principal water quality concerns include cyanobacterial bloom formation that are aesthetically undesirable and have potential for cyanotoxin formation, certain types of dissolved organic carbon (DOC) that serve as a precursor for disinfection byproducts during water treatment, and high productivity that can both elevate (during blooms) and depress (during decomposition) dissolved oxygen levels. Fluctuations in dissolved oxygen can interfere with water treatment and affect fisheries. Buffalo Pound receives its water from two principal sources, the upstream watershed and water transfers from Lake Diefenbaker to the Qu'Appelle River valley. These two water sources have vastly different concentrations of nutrients and dissolved organic carbon, with water from Lake Diefenbaker having lower concentrations. On average, most inflow to Buffalo Pound originates from Lake Diefenbaker because the majority of inflows from the local watershed are associated with spring snow melt and therefore restricted in time. However, in some years higher flows do occur from the watershed. This study will evaluate Lake Diefenbaker releases on Buffalo Pound to better understand the effect of this management option on water quality, including the effect on the reservoir's nutrient concentrations and DOC.

The Role of Reservoir Geomorphology in Determining Coverage Densities for Bathymetric Surveys in Oklahoma Water Supply Reservoirs

James Decker, Scott Robertson, Chris Adams, Julie Chambers, and Paul Koenig
Oklahoma Water Resources Board, Oklahoma City, Oklahoma

Bathymetric maps illustrate the topography of the lake bed providing key information about the depth and shape of underwater terrain. In Oklahoma, bathymetric maps are relied upon for volume information when evaluating volumetric dissolved oxygen criteria and planning water supply availability. Through the application of existing procedures and staff expertise, it is clear that spacing of transects and the frequency of data collection points plays a key role in the accuracy of the survey. The objective of this study was to determine how increased distance between transects and decreased data point frequency would affect the overall accuracy of the survey. Additionally, a key question was how the geomorphology of specific reservoirs plays a role in determining the need for higher resolution of transects and data collection. Three reservoirs were used as case studies to evaluate the influence of geomorphology on determining transect spacing and data point frequency on the overall accuracy of the survey's final lake volume calculation. Data was collected continually along pre-planned transects in each reservoir; positional data was collected using a GPS and depth data using a survey-grade echo sounder. All three surveys had a transect spacing of 75 feet and data points were collected approximately every 6 inches. The outcome of this work allows us to determine transect and data point collection needs based upon a reservoir's geomorphology. This will improve the state's ability to scope and budget mapping projects which assists lake mangers and water supply providers in long term water quality and quantity planning.

Open-Source Spectrometry for Collective Monitoring of Nutrients

Jiansheng Feng, Kelly Siman, Banafsheh Khakipoor, Adam Smith, and Hunter King
University of Akron, Akron, Ohio

We present a cellphone-camera-based spectrometer for measuring phosphorus and nitrogen concentrations in water. The combined hardware/software system is designed to meet the following goals: 1) easy to make with standard makerspace equipment and requires only low-cost, readily available materials, such that it can be affordable/accessible in many schools, makerspaces, or fablabs; 2) be simple and user friendly, such as to function as a teaching tool in K–12 water-related lesson plans and in public parks; 3) produces accurate results comparable to commercial colorimeters or spectrometers; 4) allows simple aggregation of resulting data, which is shared with the users. The

intent is to provide a much-needed supplementary data set for nutrient loading from local sources along the watershed, by local inhabitants, while promoting a tangible appreciation of water-related issues in young people.

The Use of Phoslock® as a Maintenance Measure to Control Cyanobacteria in a Large Brazilian Urban Lake Subjected to High Organic Load

Tiago Finkler Ferreira[1], Rafael Schmitt[1], Said Yasseri[2], Patrick van Goethem[3], and Nigel Traill[3]
[1]Hidroscience Consultoria e Restauração Ambiental, Porto Alegre, Brazil; [2]Institut Dr. Nowak GmbH & Co., Ottersberg, Germany; [3]Phoslock Europe GmbH, Zug, Switzerland

Lake Pampulha is an urban lake located in Belo Horizonte state, Minas Gerais, Brazil which has undergone intense eutrophication since the 1970s due to the constant input of organic loads from the main tributaries. The aim of this project was to restore the water quality of the Lake and control cyanobacteria using the lanthanum-modified bentonite clay (Phoslock®). A total dose of approximately 1000 tons of the product was applied to reduce internal phosphorus load from the sediment and external input from the catchment over 2016 and 2017. The total dose was divided into monthly applications due to the financial chronogram imposed by the contractor, the Municipality of Belo Horizonte. The treatment resulted in a significant reduction (> 94%) in total phosphorus concentrations which consequently led to a reduction of 92% in chlorophyll and 85% in cyanobacterial density. With such results, the aim of the project was achieved and the classification of the lake according to Brazilian legislation for surface waters (CONAMA 357/2005) was upgraded. The trophic status of the lake improved from hypereutrophic to mesotrophic. Additionally, positive changes in the phytoplankton and zooplankton community were also observed, with an increase in the abundance of Chlorophyceae and Bacillariophyceae. As a result of these changes and the increase in Secchi depth (0.4 to 2 m), *Daphnia sp.* were observed in the lake for the first time in decades. The success of the treatment confirms the efficiency of Phoslock® as a maintenance measure to reduce phosphorus concentrations, thereby controlling cyanobacteria, even in systems subjected to input of continuous and high organic loads.

Wisconsin's Strategy for Prevention of Aquatic Hitchhikers

Susan Graham and Amanda Smith
Wisconsin Department of Natural Resources, Madison, Wisconsin

Aquatic invasive species, otherwise known as AIS, are non-native species that can take over, spread primarily by humans, and negatively impact recreation, the economy, and our native ecosystems. Given the scale of the problem and the threat, this presentation will describe what Wisconsin is doing, how we encourage citizens to partner with scientists, and what success has looked like here. Wisconsin has a comprehensive rule called NR-40 that classifies species that are prohibited, restricted, or not a concern, and guides regulations based on risks. In addition to containment and control, we employ a multi-faceted approach to prevent the introduction and spread of AIS. For the Wisconsin DNR, preventing the spread of invasive species relies on a social science understanding of human behavior.

Relationships Between Macrophyte Communities and Salinity Among Northwest Florida Coastal Dune Lakes

★ **Richie Gray[1], Challen Hyman[1,2], and Dana Stephens[1]**
[1]Mattie M. Kelly Environmental Institute, Northwest Florida State College, Niceville, Florida; [2]Choctawhatchee Basin Alliance, Santa Rosa Beach, Florida

Coastal dune lakes of northwest Florida are mesohaline ecosystems due to intermittent connection with the Gulf of Mexico. Such connection creates a dynamic environment with variance in biogeochemical fluxes and physiochemical properties. Purpose of this study was to examine impact of salinity on macrophyte communities among a population of 15 coastal dune lakes ranging in salinity from < 1 to 14 ppt. Macrophyte surveys were conducted during low and high growing seasons in each lake. Emergent, floating, and submersed macrophyte species were identified and percent area cover determined within a 1 m quadrat every 3 m along 20 m transect from the shoreline. Sonar mapping using Lowrance side scan and structure scan units was completed to assess percent area covered, density, and depth of submersed aquatic vegetation for the entire lake. Analyses of preliminary data suggest there was a negative correlation between submersed aquatic vegetation and salinity. Certain macrophyte species were found to dominate low salinity lakes (*e.g.*, *Utricularia sp.*) and higher salinity lakes (*e.g.*, *Ruppia maritima*). Invasive species, *Panicum repens* and *Phragmites sp.*, were identified in some lakes as well. These results contribute to development of a northwest Florida coastal dune lake management plan.

An Immigrant Hypolimnion: The Role of Intrusion, Anoxia and Entrainment in Mediating Phosphorus and Trophic State Dynamics in Mona Lake, Michigan

★ **Hayden Henderson and Martin Auer**
Michigan Technological University, Houghton, Michigan

Drowned river mouth systems are common along the western shore of Lake Michigan, wherein smaller lakes are hydrodynamically linked to the larger Lake Michigan system, with the potential for significant biogeochemical impact. Mona Lake, Michigan has become eutrophic as result of cultural eutrophication. Scientific studies and associated efforts to manage in-basin phosphorus loads have failed to result in improvement in trophic state conditions. The monitoring effort and subsequent modeling (LAKE2K) reported on here has shifted the management focus to internal phosphorus loads as a necessary precursor to trophic state change. The lake's shallow depth (averaging 4.8 m) and orientation with respect to prevailing winds results in ephemeral stratification and attendant near-bottom anoxia. Sediment phosphorus release yields bottom water soluble reactive phosphorus concentrations exceeding 1 mg P/L - which become entrained and delivered to surface waters during episodic high wind events. Interestingly, the stratification-

anoxia-phosphorus release phenomenon may also be engendered by intrusions of cooler (more dense) water from Lake Michigan which then lie over the sediments as an 'immigrant' hypolimnion wherein the sediment released phosphorus accumulates between mixing events. Occurring in late summer, when spring loads and the early-season phytoplankton response have been assimilated, phosphorus entrainment has been regularly associated with blooms of potentially toxic cyanobacteria (largely *Microcystis*). Efforts to further control watershed phosphorus loads will not be made manifest in the lake's trophic state condition unless internal loading is first addressed. We look to artificial mixing as a means of eliminating both ephemeral stratification and 'immigrant' hypolimnia in accomplishing this goal.

Reverse Osmosis: An Alternative for Wastewater Nutrient Removal

Kelsey Henderson and Karen Mancl
The Ohio State University, Columbus, Ohio

Reverse Osmosis (RO) is the most commonly used membrane treatment system for water reclamation from sources contaminated with nutrients and salts. The drawbacks to RO are the high energy cost and the extensive pretreatment required for membrane treatment without immediate fouling. Extracellular polymers secreted by microorganisms affect the biological fouling potential of the effluent on the membranes, however in sand bioreactors this extracellular polymer remains in the filter and thus is at lower levels in the effluent.

RO treatment of sand bioreactor effluent should result in more limited fouling, and therefore a less rigorous cleaning and maintenance schedule of the membranes, making reverse osmosis an economically and mechanically feasible process. The experiment objectives are to: analyze the relationship between wastewater strength and rates of membrane fouling and pollutant removal; distinguish optimal membrane characteristics for treating high fat- and salt-content wastewater; and discuss the relationships between membrane fouling potentials of activated sludge effluent and slaughterhouse sand bioreactor effluent.

Four different reverse osmosis flat sheet membranes are being tested under varying pressure conditions using sand bioreactor treated slaughterhouse effluent, both with and without added 6 g/L NaCl concentration. DI water serves as a control in the experiment.

Social Marketing Maneuvers, Magic, and Measurable Change!

Jill Hoffmann[1] and Lyn Crighton[2]
[1]White River Alliance, Indianapolis, Indiana; [2]The Watershed Foundation, North Webster, Indiana

Ever wonder how to create a grassroots public education and engagement program that brings about real, measurable environmental change? How about creating a program where others pay you for the right to promote and widely share your messages about water quality? Join us and become a social marketing magician!

Clear Choices, Clean Water is a social marketing campaign focused on how the choices we make impact our lakes and streams. The program's unique strategy to increase awareness and knowledge about topics like lawn care, pet waste, native plants, and septic systems has garnered the attention and financial support of dozens of agencies, nonprofits, utilities, and municipalities. The original vision for the campaign was to change people's behavior about a handful of common water quality issues while simultaneously evaluating the success of such efforts; however, the vision has grown to also include behavior change choices related to water conservation, soil health, tree stewardship, and volunteer participation… and now, Clear Choices has grown in its geographical reach with partner organizations implementing the program in New York, Pennsylvania, Ohio, and Missouri!

We will explore how the pledge map, associated pollution reduction estimates, and various website analytics provide both immediate gratification for the pledgee and real-time evaluation for the program administrators. The objectives for the session are to teach participants how to think through what behavior changes they want; customize a program to fit their audiences; build widespread, lucrative partnerships; and implement a cutting-edge, action-focused public engagement program that transcends nearly every watershed stakeholder group.

Age Comparisons of Walleye in Select New York Waters 1991–2010

★ J.R. Hulbert[1], D.S. Stich[1], and S.M. Wells[2]
[1]Biology Department, State University of New York College at Oneonta, Oneonta, New York; [2]New York State Department of Environmental Conservation, Region 4 Fisheries, Stamford, New York

Although multiple approaches to aging fish exist, this research focused on the use and analysis of hard parts of Walleye (*Sander vitreus*). The examination of hard parts like scales, spines, otoliths (earbones), and other bony parts are the most frequently used method for aging fishes. These calcified structures often contain a record of seasonal growth patterns. However, various sources of error usually complement age determination, some of which can have a serious influence on age-structured calculations. Estimated ages from these calcified structures may not equal the true age of the fish, they may differ among technicians, or even between structures. Given the importance of age data in fisheries management, it is essential to quantify and model sources of variability, precision, quality control, and bias in age determination. There is no one way to interpret error associated

with aging, however combining age bias plots, and tests for symmetry and precision will offset any constraints characteristic in any single approach. Future work on percids in this region will investigate number of factors that influence age-length relationships.

Shifts in Phytoplankton Genera with Salinity in Northwest Florida Coastal Dune Lakes

★ **Linda Ivey and Dana Stephens**
Mattie M. Kelly Environmental Institute at Northwest Florida State College, Niceville, Florida

Coastal dune lakes of northwest Florida have intermittent breaches to the Gulf of Mexico creating dynamic changes in salinity. This study identified phytoplankton species, categorized into genera, in two of the coastal dune lakes divergent in mean salinity. Morris Lake had a mean salinity of 0.3 ppt, while Grayton Lake had a mean salinity of 10.3 ppt. Surface water samples (0.3 m) were collected with 150 mL glass amber bottles at three open-water stations quarterly (*i.e.*, winter, spring, summer, and fall) from 2017 through 2018. Samples were preserved at 3% Lugol's solution and stored until processed. Samples were run at 4×, 10×, and 20× magnification using the FlowCAM (Fluid Imaging Technologies, LLC). Phytoplankton species were enumerated and mean number of species per genera calculated among magnifications per each sampling date. Variety of phytoplankton genera were found in both Morris and Grayton lakes. However, green algae, freshwater diatoms, and cyanobacteria dominated Morris Lake throughout the year. Dinoflagellates, marine diatoms, and golden-brown algae dominated Grayton Lake throughout the year. These results target lack of known phytoplankton communities within Northwest Florida coastal dune lakes, which increases ability to manage these unique systems.

Bioaccumulation of Selenium and Mercury in Fish Tissues of an Urban Watershed and Reservoir, Denver Colorado

Nathan Jahns, Shai Kamin, and Craig Wolf
GEI Consultants, Inc., Denver, Colorado

A portion of the Cherry Creek Watershed (Denver, Colorado) sits on natural deposits of selenium-rich, sub-surface marine shales. Natural weathering results in elevated selenium water and fish tissue concentrations in tributaries to Cherry Creek Reservoir. The watershed also lies in a populated urban area, which contributes to mercury concentrations. Elevated selenium concentrations raise concern for aquatic life use in the reservoir, while the mercury concentrations raise concern for fish consumption.

In the Cottonwood and Lone Tree Creek tributaries, 85th percentile selenium concentrations often exceeded the chronic water quality criterion (4.6 µg/L) and selenium geomean whole-body fish tissue samples ranged from 6.3 to 24.6 and 12.6 to 17.5 mg/kg dry weight (dw), respectively, over a multi-year study. Water selenium concentrations differed between sites with elevated selenium typically occurring above shale. While tissue concentrations in these tributaries often exceeded the EPA whole-body tissue criterion of 8.5 mg/kg dw, muscle tissues from Walleye collected from the reservoir ranged from 2.65 to 6.0 mg/kg dw and were considerably less than the EPA muscle-based tissue criterion (11.3 mg/kg dw). The reservoir does not overlay shale and shows no reasonable potential to exceed the EPA water quality and fish tissue-based criterion.

In Cherry Creek, total mercury water concentrations ranged from 0.00065 to 0.00192 µg/L which are below the current water quality standard for Cherry Creek Basin Segment 1 (0.01 µg/L). Mercury fish tissue concentrations ranged from 0.038 to 0.162 mg/kg wet weight (ww) for multiple species. In the reservoir, concentrations ranged from 0.019 to 0.069 mg/kg ww for Walleye. All concentrations were well below the EPA tissue-based consumption criterion of 0.3 mg/kg ww.

Retention Time Analysis Through a Finite Element Model at Old Woman Creek Wetland

Yang Ju and Bohrer Gil
The Ohio State University, Columbus, Ohio

Wetlands play an important role in improving the downstream water quality. It slows down the flow from upstream and the transportation of sediments to downstream. Accurately estimate the retention time of wetlands helps us to understand the process how sediments are transported. The objective of this study is to analyze the retention time from Old Woman Creek wetland during a rainfall event. Old Woman Creek Wetland is a wetland located on the south-central shore of Lake Erie, which is part of the NOAA's National Estuarine Research Reserve network. It has approximately 61 ha wetland, extending more than 1km south to Lake Erie. A dynamic sand barrier exists between the wetland and Lake Erie, which opens and closes periodically to control the water flow. When it is open, a rapid flux of water is allowed between the wetland and Lake Erie, which maintains a relative equilibrium between the lake and the creek. A numerical hydrodynamic model, DG-SWEM, was used to model the wetland elevation during one barrier break event. A bathymetric mesh and a roughness map are created as the inputs for the model, while the upstream discharge data is used as the boundary forcing. The wetland elevation is simulated on a second time step. The results will be compared with the water depths measured at a water quality site from Old Woman Creek. The retention time is then estimated by the modeled elevation.

Long-Term Impacts by Applications of Fluridone and Triclopyr to Target and Non-Target Aquatic Vegetation Over a Fourteen-Year Period

Amanda Mahaney[1] and Emily Mayer[2]
[1]Solitude Lake Management, Shrewsbury, Massachusetts; [2]Solitude Lake Management, Washington, New Jersey

In 2005, the three basins of Lake Saint Catherine, Lily Pond, Little Lake, and the main basin, underwent a whole-lake fluridone treatment for Eurasian watermilfoil *(Myriophyllum spicatum)*. Since then, annual spot-treatments with triclopyr have been conducted. In support of the herbicide applications, late-season modified point-intercept surveys have been carried out for the purpose of documenting the presence of native aquatic vegetation and frequency of occurrence of the non-native Eurasian

watermilfoil. Fourteen years of cataloged species data allows us to examine trends and patterns over time between the long-term impacts of fluridone and triclopyr to emergent and submersed aquatic vegetation in a 950-acre northern lake.

Combining Citizen Science with Remote Sensing to Monitor Lake Storage

Grant Parkins[1], Tamlin Pavelsky[2], Sarah Yelton[1], and Megan Rodgers[1]
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Of the 20–40 million lakes in the world larger than 0.01 km^2, only a few thousand receive regular water level monitoring. On-the-ground, automated monitoring of a fraction of these lakes would incur considerable expense. However, an inexpensive staff gauge installed in a lake can be read by anyone, making this an attractive alternative if a system is in place to collect and report the data.

The Lake Level Monitoring Project (LLMP) engages citizen scientists in monitoring lake levels at regular intervals. This data is combined with lake surface area measurements, calculated using satellite imagery from Landsat8 and Sentinel 2 satellites, in an effort to understand how the quantity of water stored in lakes changes over time.

In the first year of the project, LLMP has collected more than 700 lake level and 300 lake area measurements from 11 lakes in eastern North Carolina. We have found that lake level measurements submitted by citizen scientists are highly accurate when compared to pressure transducers installed at the same sites. We have found that lake stage variations are correlated within local clusters of lakes but have found that correlations among distant lakes are not significant.

During this session, we also share strategies for developing a citizen science project, consider the motivations of citizens who participate in LLMP, and discuss feedback they have provided regarding our data reporting systems. Finally, we share plans for expanding our lake network to 200 additional lakes in the United States, Europe, and Asia within 3 years.

An Emerging Technology Using a Resilient Fabric Material for Living Shorelines

Bruce Richards and Brian Fischer
Sox Erosion Solutions, Boca Raton, Florida

Shoreline erosion contributes to excessive losses of soil and sediment, reducing habitat in freshwater ecosystems; a new living shoreline fabric approach may be the answer. Established practices of vegetative buffering and habitat restoration are of increasing importance to policy-makers, water managers, engineers, and municipal officials. There is overwhelming scientific consensus that each coastal state will experience increased erosion due to the inevitable future rise of sea level attributable to climate change; non-coastal states will follow. A relatively recent holistic approach to stabilizing shorelines is gaining international momentum utilizing a proprietary patented bioengineered material distributed by Sox Erosion Solutions of Boca Raton, Florida. This rigorous fiber technology has been in place for 18 years and has sustained shorelines with jagged rocky shores along high wave energy embankments. Native plants have been integrated into the fabric shorelines to improve buffering of nutrients particularly phosphorus which adheres to fine grain surface sediments. This presentation will show before and after data of successful installations in a relatively short temporal scale. We will examine data collected from field studies on native plant recruitment, and shoreline habitat improvement. The conclusion will highlight key lessons learned specifically for lake managers. Our presentation will also review our future research project goals as possible opportunities for students or engineering firm collaborations.

ELISA for Anabaenopeptins and Its Use for the Monitoring of Source Waters

Paige Ruthardt[1], Tom Glaze[1], Mark Aubel[2], Amanda Foss[2], and Fernando Rubio[1]
[1]Abraxis Inc., Warminster, Pennsylvania; [2]Green Water Laboratories, Palatka, Florida

Cyanobacterial harmful algal blooms occur in freshwater lakes, ponds, rivers, and reservoirs, and in brackish waters throughout the world. The wide variety of cyanotoxins and their congeners can lead to frequent exposure of humans through consumption of meat, fish, seafood, blue-green algal products and water, accidental ingestion of contaminated water and cyanobacterial scum during recreational activities, and inhalation of cyanobacterial aerosols. Cyanotoxins can also occur in the drinking water supply. In order to monitor human exposure, sensitive analytical methods such as enzyme linked immunosorbent assay and liquid chromatography-mass spectrometry are often used.

Anabaenopeptins (APs) are cyclic peptides comprised of a ring of five amino acid residues connected to an exocyclic residue through an ureido linkage. Anabaenopeptins were first isolated from the cyanobacteria *Anabaena flos-aquae*. To date at least 96 anabaenopeptins have been reported, the various congeners are structurally related. *Planktothrix*, *Nodularia*, *Microcystis*, *Lyngbya*, and *Schizothrix*, have also been reported as producers of anabaenopeptins. APs have been shown to be inhibitors of protein phosphatases and carboxypeptidase A.

An ELISA for the monitoring of anabaenopeptins was developed and utilized for the detection of these toxins on 109 source water samples obtained from 30 midwestern sites during the 2016 to 2017 time period. The samples were also characterized for microcystins concentration by ELISA; and genes assays for mcyE, 16S, and sxtA by PCR. Nineteen of the samples were analyzed by PP2A, and by a LC/MS/MS method developed by Greenwater Laboratories. The results obtained indicate that anabaenopeptins are found at high concentration (up to 103 ppb) and at a high incidence rate. Details of the methods and data obtained will be presented.

Nutrient Loading from Stormwater Systems in Dayton, Ohio

★ **Zachary M. Schultz[1], Silvia E. Newell[1], and Katie G. Norris[2]**
[1]Wright State University, Dayton, Ohio; [2]City of Dayton Department of Water, Dayton, Ohio

The Great Miami River receives nutrient inputs from agricultural runoff, urban wastewater effluent and storm water, which together have led to occurrences of high nitrate concentrations. This project focuses on phosphate and nitrate contributions from urban, suburban, and industrial storm water systems in Dayton, Ohio over the course of one year. Four outfalls of various land use types were selected to be representative of Dayton's stormwater input to the Great Miami River. These four outfall sites are sampled for nutrient concentrations twice each month, once during dry weather and once during wet weather. This year-long sampling complements two decades of annual dry weather sampling and wet weather sampling about every five years. Long-term dry weather sampling shows that stormwater nitrate concentrations have increased significantly over the last 20 years. This is the first study in Dayton to focus on outfall sampling in all seasons.

Nutrient and Trace Metal Co-limitation of Algal Blooms in the Great Lakes

★ **Jordyn T. Stoll[1], David M. Costello[1], Andrea S. Fitzgibbon[1], and James H. Larson[2]**
[1]Kent State University, Department of Biological Sciences, Kent, Ohio; [2]US Geological Survey Upper Midwest Environmental Science Center, La Crosse, Wisconsin

Efforts to reduce the frequency and extent of harmful algal blooms (HABs) require knowledge about factors that control algal growth and toxin production. While labile N and P fuel primary production, micronutrients play a lesser-understood role as the enzymatic engines that promote rapid and efficient growth and toxin production. In summer 2017, we completed a mesocosm nutrient enrichment experiment using water collected from four river mouths in Lakes Michigan and Erie that encompassed sites with little algal biomass and those with active HABs. Nutrient treatments were fully factorial, including phosphate, ammonia as N, and trace metals (Fe, Zn, Ni, Mo, Mn), and were completed in triplicate. Community composition, chlorophyll *a* as a proxy for growth and microcystin production were quantified for each bottle. Maumee Bay algal growth was independently co-limited by N and P, while toxin production was only sustained from the initial sample in the N+trace metal treatment. The North Lake Erie community shifted to ~20% greater dominance by *Microsystis spp.* in N and trace metal treatments, while growth was serially limited by P, N, and trace metals, respectively. Preliminary data suggest that microcystin concentrations in algae are decoupled from biomass response to enrichment. These data demonstrate that a multi-nutrient view of elemental requirements is needed to understand the drivers of HABs in the Great Lakes.

Some Stormwater Ponds Release Phosphorus

★ **Vinicius Taguchi[1], Tyler Olsen[2], John Gulliver[1], Ben Janke[3], Poornima Natarajan[1], and Jacques Finlay[4]**
[1]St. Anthony Falls Laboratory, Department of Civil, Environmental, and Geo-Engineering, University of Minnesota, Minneapolis, Minnesota; [2]Barr Engineering, Minneapolis, Minnesota; [3]St. Anthony Falls Laboratory, Department of Ecology, Evolution, and Behavior, University of Minnesota, St. Paul, Minnesota; [4]Department of Ecology, Evolution, and Behavior, University of Minnesota, St. Paul, Minnesota

Stormwater retention ponds are ubiquitous in many urban landscapes but are not given much consideration post-construction. High total phosphorus (TP) concentrations from pond grab sample data for 98 ponds in Minnesota suggest that urban stormwater ponds may be releasing phosphorus (P) to receiving water bodies due to high internal loading. This is alarming because retention ponds are one of the most frequently implemented stormwater control measures (SCMs) targeting phosphorus removal. Laboratory incubations of intact sediment and water cores from 5 ponds suggest that mobile-P concentrations (iron-bound P, loosely-bound P, and labile organic P) in pond sediments and sediment oxygen demand (Smax) are indicators of P release potential. Actual P release was measured under anoxic (dissolved oxygen (DO) < 1 mg/L) conditions and was observed to be negligible under oxic conditions (DO > 1 mg/L). However, in-situ field monitoring revealed that several shallow stormwater ponds in the Twin Cities Metro Area are so strongly stratified during the spring and summer months as to prevent diurnal mixing and reoxygenation of the water column from periodic storm events. Conductivity profile measurements suggest that this is likely due to chemostratification from chlorides applied as road salt during the winter months. The resulting anoxic conditions at the sediment-water interface throughout much of the year would facilitate P release into the water column and subsequently downstream receiving water bodies.

The Effects of Hydrogen Sulfide (H_2S) Within the Hypolimnion of a Dystrophic and Eutrophic Lake on Zooplankton Survival and Vertical Distribution

★ **Keiko Wilkins and Craig Williamson**
Department of Biology, Miami University, Oxford, Ohio

Oxygen (O_2) is fundamental to the survival of all aerobic organisms on Earth. Increased flux of terrestrially-derived dissolved organic matter (DOM) into lakes is causing a reduction in O_2 concentrations within the hypolimnion of lakes. O_2 depletion, including hypoxia (low O_2 < 2 mg/L) and anoxia (no O_2), has been shown to alter the vertical distribution and decrease the abundance of zooplankton. But are low O_2 concentrations themselves the greatest threat to zooplankton during periods of O_2 depletion? The proposed research will test the hypothesis that hydrogen sulfide (H_2S), a toxic gas released under anoxic conditions, is more important than the lack of O_2 in determining zooplankton survival and distribution. The additive effect of H_2S is expected to exacerbate the effects of anoxia alone potentially causing high mortality of specific zooplankton taxa and a shift in the community composition from a more predator-dominated community to a more grazer-dominated community. In order to gauge the impact that H_2S may be having on zooplankton

communities, H_2S and zooplankton depth distribution were monitored within both a dystrophic and eutrophic lake during June–August. Also, the tolerance of various zooplankton species to both anoxic conditions and anoxia coupled with H_2S was carried out. Zooplankton tolerances to anoxia alone were shown to be taxon specific with more predacious zooplankton *(Mesocyclops)* being shown to have higher tolerances to anoxia than zooplankton grazers (*Daphnia*, *Leptodiaptomus*). Also, lake water containing anoxia and H_2S had overall lower survival for all species than anoxic water alone.

Thursday, November 1

Session D1: Paleolimnological Applications for Lake Management

8:30 am – 10:00 am | West Meeting Rooms 260–261

Regional Paleolimnology Reveals Widespread Anthropogenic Impacts

Euan D. Reavie[1], Mark B. Edlund[2], Katya E. Kovalenko[1], and Joy M. Ramstack Hobbs[2]
[1]Natural Resources Research Institute, University of Minnesota Duluth, Duluth, Minnesota; [2]St. Croix Watershed Research Station, Science Museum of Minnesota, Marine on St. Croix, Minnesota

Long-term records of environmental condition are critical for diagnosing region-wide anthropogenic impacts and establishing best management practices. Extending paleolimnology from single lakes to large regions should enable detection of widespread stressors such as climate change and atmospheric deposition. Using assemblage similarity analysis on diatom paleorecords from more than 100 Minnesota lakes we characterized periods of spatially consistent assemblage changes over the last 150 years. While we expected localized stressors such as agriculture and urban development to drive assemblage reorganization in specific lakes, overarching stressors such as climate change should be discernable in the regional analysis. We hypothesized that this overarching shift would manifest as diatom assemblage reorganization from low-nutrient to higher-nutrient taxa and, more recently, species that indicate warmer atmospheric temperatures, warmer surface waters, and shifts in lake thermal structure. We specifically test whether diatom communities are stronger indicators of multiple regional stressors than other common paleolimnological proxies.

Applying Paleolimnological Techniques to Reservoirs: Challenges and Possibilities

Victoria L.S. Chraïbi
Tarleton State University, Stephenville, Texas

Paleolimnology provides useful long-term data sets and holistic perspectives of lakes that inform management. These analyses have been applied to reservoirs with mixed results. Riverine impoundments do not follow hydrological or sedimentation models similar to most natural lakes, creating obstacles for the application of paleolimnology. For example, fast sedimentation rates, dredging, and the young age of reservoirs pose issues for dating sediment and ensuring undisturbed core chronologies. However, it is worth developing modified techniques that account for the unique properties of reservoirs. There is the potential to synchronize paleolimnological studies with modern limnological monitoring in reservoirs in order to understand how reservoir-specific processes are reflected in longer-term records. Paleolimnological analysis of reservoirs is especially promising for arid regions such as Texas and the American southwest, where natural lakes do not exist from which to procure sediment cores. This will enable the application of paleolimnology to better inform long-term management for a suite of problems that face riverine impoundments, including changes in hydrology and biotic structure due to decreasing precipitation, changing seasonality, and human activities like impoundment, diversion, and irrigation.

Paleolimnological Assessment of Lakes on the Kissimmee Chain, South Florida, USA

Thomas J. Whitmore[1], Melanie A. Riedinger-Whitmore[1], Francesca M. Lauterman[1], Neil Rose[2], Handong Yang[2], Jason H. Curtis[3], Christine Leonard[1], Daniel Franklin[1], Zachary Leyton Rivera-Reed[1], Deveny E. Evans[1], and Karla Alvarado[1]
[1]University of South Florida St. Petersburg, St. Petersburg, Florida; [2]Environmental Change Research Centre, University College London, London, United Kingdom; [3]Department of Geological Sciences, University of Florida, Gainesville, Florida

The Kissimmee Chain of Lakes in south Florida consists of twenty lakes that flow southward through the Kissimmee River to Lake Okeechobee and the Florida Everglades. The lakes originally were associated with wetlands and had high-colored DOC, but reference conditions are poorly documented. Agriculture and urban development in the 20th century led to the loss of associated wetlands, and significant nutrient loading caused degradation of water quality. High nutrient conditions exert downstream effects on Lake Okeechobee and have implications for restoration of the Everglades. We present a paleolimnological study that determined reference water-quality conditions for lakes on the Kissimmee Chain. We maintain that associated wetlands and native macrophyte communities exerted important influences on lake processes, so understanding their presence during the past is essential for more holistic assessment of ecosystem change and for effective management. We collected 10 sediment cores from Lakes Tohopekaliga, East Lake Tohopekaliga, Kissimmee, and Cypress and examined sedimented diatoms, algal and cynaobacterial pigments, stable isotopes of organic matter, pollen, and sedimented macrofossils. Diatom-based statistical models indicate that pre-disturbance limnetic total P values were in the range of 40–45 µg/L. Chronologies and nutrient accumulation rates were calculated using ^{210}Pb and ^{137}Cs radionuclides. Diatoms showed progressive changes from benthic to planktonic communities during eutrophication, but with onset of cyanobacteria, planktonic forms were competitively displaced, and diatoms that depend on wind-generated resuspension became dominant. We also examine evidence of changes in wetland influences and macrophyte communities as indicated by pollen and plant macrofossils.

Innovative Approaches in Paleolimnology: How Recent Advances Can Inform Lake Management

Melanie Riedinger-Whitmore, Thomas Whitmore, Daniel Franklin, Francesca Lauterman, and Deborah L. Howard
Department of Biological Sciences, University of South Florida St. Petersburg, St. Petersburg, Florida

The protection and management of lakes require an understanding of how water quality and watershed conditions have changed through time. Paleolimnology is the standard approach used to define pre-disturbance and reference conditions, and in developing restoration goals and best management practices. Common paleolimnological methods employed in lake management studies include analyses of biological fossils and sediment geochemistry. Recent analytical advances in UV-Vis Near-infrared spectroscopy (NIRS) and in molecular techniques supplement these classic approaches and provide the opportunity to use the paleolimnological record to explore a new suite of questions that can address contemporary lake-management issues. NIRS uses multivariate statistics to analyze absorption spectra (400–2500 nm) and to determine the physical and chemical properties of sediment samples. Regional calibration data sets have been developed to assess algal productivity, nutrients, organic compounds, and contaminants in surface sediment and core samples. NIRS is a rapid, non-destructive technique that permits sample absorption spectra to be archived for use in future studies. In applied metagenomic studies, environmental DNA is extracted and sequenced from sediments using molecular techniques and can be used to document aquatic organisms that do not leave recognizable fossils. Sedimentary DNA has been used to examine population and community-level questions related to algae, zooplankton, bacteria, and fungi. This approach also has been used to examine historical changes in aquatic biodiversity. We present examples of how we are using these approaches in our paleolimnological research in Florida, and we discuss how they are applicable to lake management.

Session D2: Lake Management and Restoration

8:30 am – 10:00 am | West Meeting Room 262

Nutrient Management Challenges in Coeur d'Alene Lake, Idaho

Craig Cooper
Idaho Department of Environmental Quality, Coeur d'Alene, Idaho

Coeur d'Alene Lake is a primarily oligotrophic lake that is a critical economic and cultural resource for northern Idaho. The lake also holds over 75 million tons of metal contaminated sediments that result from historic mining practices and is part of the Bunker Hill Superfund action. The metal contaminants are managed in place via a lake management plan that seeks to sustain high levels of hypolimnetic oxygen in order to trap metals within the sediments and facilitate long term remediation and restoration. Oxygen levels in the lake are managed by limiting productivity via a nutrient management strategy. These actions also support managing overall lake water quality for beneficial use. Harmful algae blooms occur in nearby lakes and are also a potential challenge for Coeur d'Alene Lake. Trend analyses indicate that, except for lead, dissolved metals levels are declining in the lake. In contrast, trophic status is trending towards a more productive system. These factors increase the risk of metals remobilization from the sediments and pose a long-term nutrient and oxygen management challenge. Phosphorus loads are increasing in many of the Coeur d'Alene Basin's watersheds and are primarily non-point source. Potential drivers of these changes will be discussed within the context of the known and unknown factors, as well as nutrient management activities.

Managing Large Inland Lakes: The Need for an Integrated Management Approach for Successful Lake Management

Jennifer L. Jermalowicz-Jones
Restorative Lake Sciences, Spring Lake, Michigan

Although an integrated lake management approach could be applied to most lakes, it is especially important for the successful management of large (> 1,000 acre) inland lakes. This evaluation focuses on Houghton Lake which is a 22,044-acre natural, glacial lake located in northern Michigan. The lake has two sizeable bays and several major tributaries and an outlet to the Muskegon River at the north region of the lake. In addition, the lake has over thirty canals that are developed. The lake has approximately 30.5 miles of shoreline and a mean depth of approximately 8.5 feet, so it is vulnerable to aquatic invasive species and water quality degradation.

Each component of the lake (*i.e.*, bays, tributaries, flats, canals) is being managed with different methods and technologies since the problems associated with each area are unique and vary at the spatial level. Such methods include replanting of native wild rice in the north bay of the lake, reduction of invasive hybrid watermilfoil and starry stonewort throughout the entire lake, application of laminar flow aeration and bioaugmentation to certain impaired canals, and implementation of nutrient and solid filters to tributaries that were associated with increased pollutant loads. Specialized planning for each improvement type was needed in order to assure the Houghton Lake Improvement Board and the Houghton Lake community that the myriad issues facing the lake could individually be addressed and ultimately lead to substantial gains in the overall ecological balance of the lake.

Results of Innovative Restoration Techniques at Lake Apopka, Florida

Erich Marzolf
St. Johns River Water Management District, Palatka, Florida

Lake Apopka is a shallow, 30,800-acre eutrophic lake in central Florida. The lake's health is challenged by three threats; eutrophication due to excessive phosphorus (P) loading, wildlife effects of residual organochlorine pesticides (OCPs) and severe multi-year droughts which significantly impact water levels, water quality and critical habitats. To address these threats, the St. Johns River Water Management District (District) is implementing a multi-part restoration program which utilizes a variety of innovative techniques to address each threat. To remove excess bioavailable P from the lake's water, the District

is operating a 760-acre recirculating filter marsh which annually filters approximately 40% of the lake's volume. From 2003 to 2017, 119 million pounds of suspended solids and 71,355 pounds of P were removed. In addition, a rough fish harvest program removed 26.5 million pounds of fish (217,500 pounds of bioavailable P) between 1994 to 2016. Wildlife exposure to OCPs was reduced by implementing a novel soil inversion technique which buried the contaminated top foot of soil under four feet of cleaner underlying soil. This inversion technique was applied over 4,000 acres, and reduced remediation costs by > 95% when compared to traditional soil remediation techniques. To address water availability, the District is planning two projects: one to increase flood protection by temporarily storing water for subsequent lake level augmentation and second, a large solar panel farm which in addition to reducing electricity costs, will increase water yield by reducing evapotranspiration losses from a project area and reduce water used to generate steam at powerplant.

Pacification: The New Narrative on Lake Management

Dick Osgood
Lake Advocates, Duluth, Minnesota

The theme for this conference, "Innovations in Lake Management," suggests we are on track to address lake management challenges. Yet, nearly 50 years after the Clean Water Act, the quality of the nation's lakes, on average, has not changed. And new threats are emerging - invasive species, climate change, HABs, intensified agriculture and increasing population. Our narrative emphasizes all that is being done to protect, manage and restore our lakes - diverting our attention from the realities. Trends are going the wrong way and positive outcomes are lacking overall. Here, I examine narrative and realities of the management of Minnesota lakes. I find that 18-times more phosphorus-impaired lakes have been added than removed from the impaired waters list annually, there are 1,200 mercury-impaired lakes (none have been removed), chlorides are impacting urban lakes and there are no plans to remedy this, aquatic invasive species infestations continue despite increased awareness and inspections, and the prevalence and intensity of harmful algae blooms is increasing. All this despite the investment of 100s of millions of dollars annually. Our narratives emphasize partnerships, watersheds, busy hands and an overall can-do attitude with the effect of de-sensitizing or distracting from the elephants in the room - water quality impacts of agriculture, lack of measurable progress in lake quality, climate change, invasive species and road salt use. What can be done and what is the role of lake managers?

Session D3: Remote Sensing

8:30 am – 10:00 am | West Meeting Room 263

Use of Remote Sensing Techniques to Monitor Harmful Algal Blooms

Christian Corbeil and Julie Camy
Groupe Hémisphères, Québec, Québec, Canada

Under the increasing effects of climate change, the phenomenon of harmful blue-green algae (or cyanobacteria) algal blooms continues to intensify in lakes across North America. Indeed, the ability of some species of cyanobacteria to produce toxins is a significant problem for public health and for recreational use.

The SCHORE (System for CHlOrophyll Remote Estimation) application has been developed to become one of the most innovative computer tools in terms of monitoring the water quality of lakes. Traditional cyanobacteria monitoring methods are based on visual observations and punctual sampling performed following the observation of excessive proliferation of cyanobacteria in lakes and streams. SCHORE allows for the remote estimation of the concentration of a green pigment present in water, chlorophyll *a*, which is used as an indicator of the presence, spatial distribution and concentration of cyanobacteria in freshwater lakes.

SCHORE is available in two versions, which produces daily or weekly maps of the spatial distribution of chlorophyll *a*. The application relies on high-resolution imagery (LANDSAT and SENTINEL), which allows it to be used on lakes larger than 2 ha. The Chl-*a* estimation maps are then integrated into a technical sheet which presents environmental and meteorological data available at the time of the analysis.

This presentation aims to present a complementary decision-making tool for lake quality monitoring or the implementation of preventive actions to be taken at the watershed level. A concrete application will be presented concerning the protection of a drinking water source.

Cyanobacteria from Space: Satellite Imagery for Bloom Monitoring

★ **Igor Ogashawara and Lin Li**
Department of Earth Sciences, Indiana University-Purdue University at Indianapolis, Indianapolis, Indiana

Cyanobacterial blooms (CBs) have been a concern especially for inland waters. Traditional monitoring methods usually are not suitable for monitoring CBs on large spatial and temporal scales, but remote sensing has been used to fill this gap. Remote monitoring of CBs relies on the optical properties of pigments. While few orbital sensors can measure it, the Ocean and Land Color Instrument (OLCI) on-board the Sentinel-3 satellite has the adequate spectral resolution. The goal of this study is to evaluate OLCI's potential to identify CBs. To do this, OLCI images were collected over the Western part of Lake Erie (USA) for the summer of 2016 and 2017. An analysis of single spectral bands and band ratios was used to explore the use of satellite imagery for the estimation of PC. Using the combination of both datasets, none of the single bands shown to be correlated with PC

concentrations ($R^2 < 0.1$). For the band ratio analysis, the highest R^2 was 0.26 for the ratio between bands centered at 709 nm and 673 nm. This low performance is attributed to low concentrations of the pigment (average concentration 3.49 mg/m^3). When using only concentrations higher than 10 mg/m^3, the highest R^2 was 0.87 for the ratio between 412 and 709 nm. These results show that OLCI can be used to identify CBs. However, more work is needed for the estimation of low pigment concentrations. By solving these issues, remote sensing can be used to support water quality management.

Remote Sensing of Harmful Algal Blooms and Water Quality Characteristics in Kentucky Lakes

Colin Arnold
Kentucky Division of Water, Frankfort, Kentucky

Lakes are a valuable economic and environmental resource for the Commonwealth of Kentucky. The Kentucky Division of Water (KDOW) currently monitors 108 of approximately 200 lakes greater than 25 acres in size that are located within the Commonwealth. These lakes are currently monitored following a five-year rotation among designated basin management units. Due to resource limitations, KDOW is investigating the use of free Landsat 8 and Sentinel 2 satellite imagery in order to estimate water quality in unsampled lakes and assist in harmful algal bloom monitoring. Remote sensing has been successfully used in other states to predict Secchi disk transparency. In 2017, Watershed Watch of Kentucky and KDOW partnered to initiate a pilot program for citizen volunteers to assist with lake monitoring. A primary goal of this volunteer monitoring program is to be able to assist with the detection of harmful algal blooms within the Commonwealth. From June through October of 2017, 10 volunteers collected a total of 42 Secchi disk transparency measurements from 10 locations on Herrington Lake, correlating sample dates with Landsat 8 overpass. KDOW used this data along with atmospherically corrected satellite imagery via Landsat 8 to predict Secchi disk transparency for the lake. A stepwise regression was used to determine an appropriate equation which accurately predicts Secchi disk transparency for Herrington Lake. In 2018, the study will continue with the possibility of including chlorophyll *a* measurements for Herrington Lake and additional sites for Secchi disk measurements.

Session D4: Ecological Engineering of Sustainable Landscapes to Protect Downstream Aquatic Ecosystems

8:30 am – 10:00 am | West Meeting Room 264

Sustainably Solving Legacy Phosphorus and Nitrogen in Landscapes with Wetlands and Wetlaculture

William J. Mitsch
Everglades Wetland Research Park, Florida Gulf Coast University, Naples, Florida; School of Geosciences, University of South Florida, Tampa, Florida; The Ohio State University. Columbus, Ohio

The world is faced with unprecedented threats to our aquatic ecosystems from excessive nutrients caused especially by agricultural and urban runoff. More than 750 aquatic ecosystems suffer from degraded ecosystem services with impairments described as hypoxia, dead zones, and harmful algal blooms, most due to pollution caused by excessive nitrogen and phosphorus. At the same time, it has also been estimated that, on a global scale, we have lost half of our original wetlands to our current extent of 8 to 12 million km^2, with most of that loss in the 20th century. We are proposing here a sizeable increase in the wetland resources around the world to solve the diminishing wetland problem but with the strategic purpose of mitigating the excess phosphorus and nitrogen in a sustainable fashion. Examples include minimizing phosphorus inflows to the Florida Everglades with treatment wetlands and reducing nutrient inflows to Lake Erie in the Laurentian Great Lakes by restoring parts of the Great Black Swamp, formerly a 400,000 ha wetland west of Lake Erie. The status of our wetlaculture physical models (mesocosms) in Ohio and Florida for solving nutrient saturation of our landscapes and aquatic ecosystems and recycling (flipping) those nutrients back to agriculture—defined as wetlaculture—will be described. Our mesocosm experiments in south Florida (analog of the Florida Everglades) and in NW Ohio (analog of a restored Great Black Swamp) will be presented.

Nutrient Retention by Wetland Mesocosms in the First Year of a Wetlaculture Hydrologic Experiment at Buckeye Lake, Ohio

★ **Bingbing Jiang[1,2] and William J. Mitsch[2,1]**
[1]School of Geosciences, University of South Florida, Tampa, Florida; [2]Everglades Wetland Research Park, Florida Gulf Coast University, Naples, Florida

Nutrient overloads have caused problems in aquatic ecosystems around the world for decades. As nutrient retention by wetlands is complicated, understanding of wetland functions is needed to avoid failed management of restored wetlands or inappropriate design of created wetlands. A 28-mesocosm wetlaculture (wetland + agriculture) compound using 1 m^2 mesocosms was constructed in 2016 and planted in October 2016 with the sedge *Schoenoplectus tabernaemontani*. Initial soils showed P concentrations of 519 ± 12 (9) µg/mL and N concentrations of 0.20 ± 0.01 (9) %. Bi-weekly water quality sampling began in April 2017 of soluble reactive phosphorus (SRP), total phosphorus (TP), nitrate+nitrite (NO_3+NO_2-N), total Kjeldahl

nitrogen (TKN), and total nitrogen (TN) in mesocosm inflows and outflows. The mesocosms were randomly assigned to a 7 × 2 × 2 hydrologic experiment involving 2 water depth and 2 hydraulic loading rates (HLR). Early data in 2017 suggest the mesocosms are already sinks of phosphorus and nitrogen, probably because they were constructed in an area that has not been farmed recently. The mesocosms were nutrient sinks, with a removal rate of TP (26 ± 6% (n = 111) and TN 36 ± 3% (n = 224)). Comparing the different hydrological conditions, shallow-water level mesocosms showed higher removal rates of TP (44 ± 8%, n = 55), than did deep-water level mesocosms (9 ± 10%, n = 56). The potential applications and limitations of applying these results to full-sale wetlaculture demonstration projects will be discussed. This wetlaculture study could eventually demonstrate the potential of nutrient retention by wetlands with subsequent recycling back to agriculture/horticulture in the Buckeye Lake region.

Constructed Wetlands and Nutrient Removal in Grand Lake St. Marys Watershed

Stephen J. Jacquemin[1], Phillip Poore[1], Gestawn McDonald[1], Jocelyn Birt[1], and Theresa Dirksen[2]
[1]Wright State University – Lake Campus, Celina, Ohio; [2]Mercer County Community and Economic Development, Celina, Ohio

Constructed wetlands can be an important management tool to reduce nutrient rich agricultural runoff. The objective of this study was to assess removal efficiency of two constructed wetlands on tributaries of Grand Lake St. Marys (Prairie Creek and Coldwater Creek). Both wetlands are approximately 30+ acres, situated in glacial till Blount soils typical of northwest Ohio, and consist of a series of increasingly shallow pools planted using a mix of emergent wetland vegetation (*e.g.*, grasses, sedges, rushes, forbs, shrubs). The wetlands draw stream water at a set rate using a variable pump (between 1 and 3 million gallons per day) and exhibit residence times of 1 to 3 days depending on flow and volume. For this study, water samples were collected weekly 2017–2018 (n = 46) from inflow and outflow points where they were analyzed for nutrient (nitrate-N, total phosphorus, dissolved reactive phosphorus) concentrations following EPA colorimetric methods. Overall, while both wetlands experienced high mean nutrient inputs (concentrations in mg/L) ranging from below detectable limits to 19.1 NO_3^-, 2.5 TP, and 1.1 DRP, high removal efficiencies (often > 75%) produced significantly reduced outflow concentrations (*paired t tests*; $p < 0.05$) largely consistent with EPA recommended TMDL target values for watersheds of this size (~20 mi^2: 1.0 mg/L NO_3, 0.10 mg/L TP). Mean monthly stream discharge rates compared with wetland discharge data (continuously monitored using pressure transducers) revealed that both wetlands processed between 10% and 100% of monthly flows, depending on the season. This study demonstrates the importance of constructed wetlands towards watershed restoration.

Understanding the Role of Wetland Ecoservices in Protecting Water Quality from Potential Zoonotic Pathogen Spread: *Arcobacter* Transmission Dynamics in western Lake Erie wetland and Adjacent Swimming Beach

Chris Rea[1], David Hsu[2], Cheonghoon Lee[1], Chenlin Hu[1], and Jiyoung Lee[1,3]
[1]College of Public Health, Division of Environmental Health Sciences, The Ohio State University, Columbus, Ohio; [2]Environmental Science Graduate Program, The Ohio State University, Columbus, Ohio; [3]Department of Food Science & Technology, The Ohio State University, Columbus, Ohio

Arcobacter spp. presence and spatiotemporal variability was studied in Canada Geese *(Branta canadensis)* and waters of a wildlife dense wetland and adjacent swimming beach of southwestern Lake Erie, Ohio, USA from May 2012 to April 2013. Molecular techniques, including qPCR targeting 23s rDNA, were used to detect, identify, and quantify *Arcobacter* spp. in water and fecal samples. A human microbial source-tracking marker (HF183) was also used. *Arcobacter* presence was identified at each of the water-sampling sites during the year and in 75.8% (n = 72) of all the water samples but was not found in Canada Geese fecal samples nor was human fecal contamination detected. The mean *Arcobacter* gene copy number/mL for all sites was 3.1×10^3. Phylogenetic analysis indicated *Arcobacter* sequences were closely related to *A. butzleri*, the most prevalent and hazardous species to human and animal health. *Arcobacter* concentrations and prevalence were highest at sites where water enters the wetland and levels were reduced by the wetland. Likely *Arcobacter* contamination sources were determined to be avian species; however, agricultural run-off may also contribute. This study demonstrates *Arcobacter* presence in a large freshwater lake where the predominant influence on water quality is agriculture and wildlife. Establishing *Arcobacter* presence throughout Lake Erie, and the Great Lakes more generally, is important when considering human and animal exposure risks. Conserving healthy near shore wetlands is important to support safe surface water and may aid in the control and prevention of human and animal illness.

Session D5: Phoslock

8:30 am – 10:00 am | South Meeting Rooms 237–238

Whole-Lake Combined PAC-Phoslock Treatment to Manage Eutrophication and Cyanobacteria

★ Maíra Mucci[1], Guido Waajen[2], and Miquel Lürling[1]
[1]Aquatic Ecology & Water Quality Management Group, Wageningen University, Wageningen, The Netherlands; [2]Water Authority Brabantse Delta, Breda, The Netherlands

Lake de Kuil (The Netherlands, 6.7 ha, maximum depth 9 m) suffered from cyanobacterial blooms since the early 1990s as a consequence of eutrophication. To control internal loading and cyanobacteria the lake was treated with a low dose of flocculent (4 tons of iron chloride) and a solid phase phosphate sorbent (42 tons of Phoslock®) in May 2009. The treatment aimed to target both dissolved and particulate phosphate, and to block P-release from the sediment. The treatment was successful reducing total

phosphate, chlorophyll *a* and increasing water quality. Ongoing diffuse P-inputs, however, have gradually moved the lake back towards a eutrophic state. Thus, a re-application of flocculent and Phoslock® and flocculent (polyaluminium chloride, PAC) was done in May 2017. We have been monitoring the lake before, during, and after the application. Water samples over depth were taken to analyse nutrients, chlorophyll *a*, turbidity, cyanotoxins and pH. *In situ*, Secchi depth and oxygen concentration were measured. Internal loading was monitored before and after the treatment. On May 8, 10.5 tons of Phoslock® were applied to the lake (30 mg/L) as ballast to sink the algae. The day after, 6000 L of Polyaluminium chloride were applied (2.1 mg Al L^{-1}) to flocculate the cells, while on May 10, 22.05 tons of Phoslock® were injected in the hypolimnion layer (at 5.5 meters) to target the internal loading. The results of the monitoring will be presented shedding light on the efficacy and durability of the treatment.

Evaluation of a Whole-Lake Eutrophication Management Technique Using Combined Flocculation and *In situ* Phosphorus Immobilization

★ **Frank van Oosterhout, Maira Mucci, and Miquel Lurling**
Wageningen University, Wageningen, Gelderland, The Netherlands

Cyanobacterial blooms led to swimming bans in Lake Rauwbraken (The Netherlands). System analysis revealed that this lake was eutrophicated by external phosphorus (P) loads (1.51 mg P m^{-2} day^{-1}) which over 40 years led to 15.1 mg P m^{-2} day^{-1} internal load from legacy P in the sediment. Thus, to manage eutrophication and mitigate cyanobacterial blooms the lake was treated by combining a low dose of flocculent (polyaluminium chloride) with a solid phase phosphate fixative (Phoslock®) in April 2008. Based on two years pre- and ten years post-treatment monitoring, the annual means of Secchi depth increased from 3.5 to 4.2 m and hypolimnetic oxygen concentration from 0.86 to 5.02 mg l^{-1}; turbidity decreased from 5.5 to 2.0 NTU, chlorophyll *a* concentrations from 16.5 to 5.4 µg l^{-1}, the percentage of cyanobacteria from 64% to 15%, total P from 154 to 18 µg l^{-1} and total nitrogen from 0.96 to 0.36 mg l^{-1}. The release of filterable reactive phosphate from the sediment reduced from 15.1 mg P m^{-2} day^{-1} pre-treatment to 1.7 mg m^{-2} day^{-1} post-treatment in 2008, 2.3 mg m^{-2} day^{-1} in 2011 and 4.7 mg P m^{-2} day^{-1} in 2013. The treatment successfully improved water quality and no swimming bans occurred till then. However, post-treatment significant trends downwards in Secchi depth and the increased in P-release from the sediment indicate that after 10 years of intervention the lake is returning to a eutrophic state as a result of the ongoing external P-loads.

Control of Floating Algal Mats in a Highly Frequented Recreational Lake

Karin Finsterle[1], Tim S. Epe[2], Said Yasseri[2], and Karin Pall[3]
[1]Phoslock Europe GmbH, Zug, Switzerland; [2]Institut Dr. Nowak GmbH & Co. KG, Ottersberg, Germany; [3]Systema Bio- & Management Consulting GmbH, Vienna, Austria

Benthic, mat-forming cyanobacteria in freshwater systems are an increasing phenomenon in many parts of the world. Apart from being a risk for human health when they rise to the surface, the mats also present aesthetic problems, limit recreational activities and thus can adversely affect local economies. We present results from a pilot project conducted on a small, highly frequented recreational lake in Austria, where the occurrence of floating algal mats negatively affected the ecosystem service provided by the lake. A comprehensive systems analysis of the water body revealed a dynamic chain of physical, chemical and biological interactions between the catchment, water column and sediment which trigger the formation of benthic, mat forming algal conglomerates. On the basis of our system analysis, a two-step management strategy was developed to achieve the dual targets of ecological recovery and ecosystem service preservation. In the first phase, a targeted application of lanthanum modified bentonite (LMB, Phoslock) reduced the available phosphorus fraction in the sediment and established the desired pre-conditions necessary for the growth of macrophytes. The second phase consisted of systematic and accurate planting of selected Charophyte species, typical for this environment. The results demonstrate that the adopted management concept is a promising technique to tackle the proliferation of benthic algal mats.

Phoslock® Research in The Netherlands

Miquel Lürling[1], Frank van Oosterhout[1], Maíra Mucci[1], and Guido Waajen[2]
[1]Wageningen University, Wageningen, The Netherlands; [2]Water Authority Brabantse Delta, Breda, The Netherlands

During the heat wave year 2006, many lakes and ponds in The Netherlands were suffering from massive cyanobacteria blooms. Legacy phosphorus (P) in lake beds and diffuse loading are viewed as the main sources fuelling those blooms, because point sources have been tackled adequately in The Netherlands; full compliance with the EU Urban Waste Water Treatment Directive and many WWTP have an additional third treatment step to remove phosphate and nitrogen. To improve water quality and mitigate cyanobacterial nuisance, research was directed to in-lake measures effectively targeting legacy P and diffuse groundwater P load. Phoslock® was identified as promising tool and since summer 2006 Phoslock® research started, first in the laboratory which was up scaled to enclosure experiments and to large scaled compartment experiments. In two urban ponds, 300 m^2 and 400 m^2 compartments were created that received different treatments: dredging, fish stock manipulation and Phoslock® addition. The treatments tackling internal loading (dredging and Phoslock® addition) improved water quality noticeably. Water clarity improved to bottom sight, chlorophyll *a* was reduced below 10 µg/l and submerged macrophytes reached almost complete cover. The control and fish stock manipulated compartments remained turbid, chlorophyll *a* concentrations reached as high as 100–300 µg/l and submerged macrophytes were virtually absent. Sediment P-release was reduced in the Phoslock® treated compartments and lanthanum was clearly elevated in the first 5 cm sediment after two years. Evidently, chemical P-fixation using Phoslock® is cheaper than sediment removal in urban ponds and as effective in bringing water quality to a more acceptable state.

Session E1: Paleolimnological Applications for Lake Management

10:30 am – 12:00 pm | West Meeting Rooms 260–261

Multi-Indicator, Ecologically Based Paleolimnological Studies Help Optimize Lake-Management and Restoration Strategies

Thomas Whitmore[1], Carl D. Sayer[2], Helen Bennion[2], and Thomas A. Davidson[3]
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In the last four decades, paleolimnological studies have served an important role in assessing human impacts on lakes for which pre-disturbance water-quality data are scarce or nonexistent. Statistical modeling has provided quantitative estimates of change in pH from acid precipitation, change in limnetic nutrient concentrations, and change in climate. With respect to eutrophication, lake management has focused greatly on past limnetic nutrient inferences because nutrients lend themselves to mitigation. Lake managers and freshwater ecologists, however, have become aware that reducing nutrient loads does not adequately restore systems because eutrophication is multifactorial and involves complex changes in food webs and lake processes. Applied paleolimnological studies help optimize management strategies based on site-specific conditions and drivers. This presentation examines ecologically based paleolimnological approaches that involve multiple biological indicators, particularly keystone groups such as aquatic plants. Studies that examine long-term changes in indicator groups such as diatoms, zooplankton, macrophytes, algae, cyanobacteria, and pollen evidence of associated wetlands are capable of providing more comprehensive description of system change and its causes. Changes in lake systems are often perceived as catastrophic and sudden, but careful paleolimnological studies have demonstrated that change is often a progressive succession that occurred over a time scale of many decades. A more complete understanding of long-term system change enables us to better identify Early Warning Indicators that can be used to more effectively monitor and protect lake systems, and to avoid changes that are irreversible or costly to mitigate.

The Long-Term Effects of Multiple Environmental Stressors on Shifting Benthic Production in a Large Shallow Lake

★ **Michael Murphy[1] and Jesse C. Vermaire[1,2]**
[1]Department of Geography and Environmental Studies, Carleton University, Ottawa, Ontario, Canada; [2]Institute of Environmental Science, Carleton University, Ottawa, Ontario, Canada

White Lake is a large, shallow (mean depth 3.1 m) lake located in Eastern Ontario, Canada, and an important recreation and tourism site in the region. Similar to many lakes in the area White Lake is experiencing multiple environmental stressors including nutrient enrichment, climate warming, and the recent colonization by the invasive zebra mussels *(Dreissena polymorpha)*. Lake users and property owners are increasingly concerned about water quality changes in the lake and management plans for the lake require an understanding of how these multiple environmental stressors are interacting to impact water quality. Unfortunately monitoring data for White Lake only begins in 2014 and therefore no information exists on pre-impact conditions in the lake and how these environmental stressors have interacted to alter water quality in the system. To assess long-term water quality changes in White Lake in response to these multiple environmental stressors, two sets of replicate sediment cores have been obtained from the lake, dated using ^{210}Pb, and sectioned at 0.5 cm intervals for organic content and diatom analysis. Diatom analysis suggest that the lake was becoming increasingly eutrophic since ~1980, however the recent invasion by zebra mussels has reversed this trend with diatoms suggesting nutrient limitation in the open water environment. Recent monitoring data indicates that the zebra mussel invasion has increased the percent of the lake bottom with sufficient light for photosynthesis from 20% to 90% of the lake area. These data suggest that White Lake is becoming an increasingly benthic system and that colonial benthic algae and/or macrophyte cover will expand within the lake. This research provides insight into how zebra mussels impact primary producers in shallow lakes that are sensitive to shifts in nutrients and turbidity.

Session E2: Lake Management and Restoration

10:30 am – 12:00 pm | West Meeting Room 262

Development of the Mill Pond Remediation Plan

Stephen J. Souza, Christopher Mikolajczyk, and Jesse Smith
Princeton Hydro, LLC, Ringoes, New Jersey

Mill Pond, located in Water Mill, Suffolk County, New York is a 92-acre freshwater lake. It is categorized by NYSDEC as eutrophic and has at times been impacted by cyanobacteria (blue-green algae) blooms. The measures taken over the years by the Mill Pond Association (MPA) and the Town of Southampton (TOS) to address the occurrence of cyanobacteria blooms have included the installation of a solar-powered aeration system and the application of the nutrient sequester Phoslock. Reportedly, neither the aeration system nor the PhosLock treatment yielded any long-term positive water quality benefits. Given the pond's eutrophic status, continued problems with cyanobacteria blooms, and the less than desired benefits attained through past restoration efforts, the TOS and the MPA engaged Princeton Hydro to conduct a detailed, comprehensive lake and watershed study and use the resulting data to prepare a "remediation plan" for Mill Pond.

This presentation discusses the in-lake and watershed data developed in support of the Mill Pond remediation plan, details the study's findings and discusses the proposed elements of the plan. Details are provided of Mill Pond's hydrologic budget, external nutrient loading, the relative importance of legacy agricultural loading and the impacts related to bioturbation attributable to an invasive carp population. The presentation shows how the combination of measured and modeled data were used in the development of the plan and the key strategies recommended to lessen the occurrence and severity of cyanobacteria blooms.

A Model-Based Approach for Developing Lake Management Plans

Seyoum Yami Gebremariam, Paul McCormick, and Paul Rochelle
Metropolitan Water District of Southern California, La Verne, California

The development of lake management plans requires a solid understanding of past as well as present hydrologic and water quality conditions. Reconstructing historical conditions for most lakes is hampered by limited data availability and an absence of information on many key environmental parameters. Hydrodynamic and water-quality modeling tools can address this problem by allowing key time-series data sets to be generated with relatively modest data input requirements. We used the CE-QUAL-W2 model to reconstruct 15 years of lake-wide hydrologic and water quality history for Diamond Valley Lake, a large drinking-water-supply reservoir in southern California. Available input data was limited to: 1) daily flow and lake stage data; 2) monthly water-quality data at a single station; and 3) available meteorological data from nearby weather stations. The model was successfully calibrated to simulate numerous hydrologic and water-quality parameters over the period of record and allowed for the identification of critical tipping points in time when the lake experienced changes in trophic state (*e.g.*, nutrient levels and sediment nutrient release, phytoplankton growth rates, hypolimnetic anoxia) from the baseline condition. The model was used to develop a lake management plan based on this historical information and an assessment of various management scenarios for improving future water quality.

Implementation and Results of a Comprehensive Urban Shallow Lake Monitoring Plan to Understand Ecosystem Dynamics and Inform Holistic Lake Management

Sarah Wein, Britta Suppes, and Bob Fossum
Capitol Region Watershed District, Saint Paul, Minnesota

Como Lake is a 70.5-acre urban shallow lake located within Capitol Region Watershed District (CRWD) in St. Paul, Minnesota. Shallow depth, coupled with large nutrient inputs from runoff, have had significant negative impacts to the lake's overall health. Como Lake experiences frequent summer algal blooms and has been listed as impaired for nutrients, chloride, and mercury. Water chemistry and physical parameters have been collected since 1984, but additional monitoring was needed to better understand in-lake water quality drivers and ecosystem dynamics. In response, CRWD implemented a comprehensive monitoring plan in 2014. This enhanced monitoring plan increased: data collection of the biological community (aquatic macrophytes, fish populations, phytoplankton, and zooplankton); the frequency of physical/chemical data collection, including winter monitoring; and the collection of continuous hypolimnetic dissolved oxygen at multiple locations. Sediment cores were also extracted to measure phosphorus release rates. Analysis showed that Como Lake has a low-diversity plant community and an overabundance of curly-leaf pondweed, an imbalanced fishery consisting mainly of planktivorous fish, and a phytoplankton community dominated by blue-green algae. Data also revealed that hypolimnetic phosphorus significantly increased recently and that the lake has extended periods of anoxia. Results indicate that internal loading is the primary source of phosphorus to the lake. Managing key drivers of internal loading (anoxia, plant senescence, fishery imbalance) will be critical for restoring balance to the lake. This additional data will guide the development of the 2018 Como Lake Management Plan which will define adaptive management strategies for meeting long-term water quality goals.

Too Many Innovations? Recent History on a Multi-Dimensional Small Lake Restoration – Mountain Lake, San Francisco

Alex Horne
University of California, Berkeley California

Mountain Lake, one of only three natural lakes in San Francisco, recently was restored using an innovative mixture of extensive dredging and bottom and shore reshaping, watershed wetlands construction, biomanipulation (replacement of all higher trophic levels, exotic tree removal from riparian zones, planting leafy submerged aquatic plants), and two aeration methods. In the first year, TP, ammonia, and sediment anoxia dropped; chlorophyll and nitrate less so but Secchi depth doubled, and this urban lake became almost mesotrophic. The next year was California's wettest and followed a 4-year drought. As expected, nitrate rose six-fold but, surprisingly, TP did not (TP not correlated to salinity, but nitrate was). A huge blue-green algae bloom arose in lake spring and was traced to two causes: the high spring nitrate &/or an unusual fault in the aeration system. Once the aeration was corrected by mid-summer, internal loading of nutrients and blue-green scums declined but not sufficiently to restore the past years higher water quality. Several lessons learned include 1) aeration pipe joints can leak silently, 2) there is a month's lag between aeration on and effects on sediment nutrient releases but no lag for getting oxygen into deep water for the biota, 3) in urban settings, control of watersheds nitrate requires more active wetlands or nitrate trenches while TP control may only need storm water wetlands or other good BMPs, 4) the results or too many innovations at once are tricky to interpret!

Session E3: Innovations

10:30 am – 12:00 pm | West Meeting Room 263

Building a Smart Lake Erie: Intelligent Water Management as a Regional Economic Driver

Max Herzog[1], Bryan Stubbs[1], Chris Winslow[2], John Bratton[3], Ken Loparo[4], Dorothy Baunach[5], Laura Johnson[6], George Bullerjahn[7], and Sudhir Kshirsagar[8]
[1]Cleveland Water Alliance, Cleveland, Ohio; [2]Ohio Sea Grant, Columbus, Ohio; [3]LimnoTech, Ann Arbor, Michigan; [4]Case Western Reserve University, Cleveland, Ohio; [5]DigitalC, Cleveland, Ohio; [6]Heidelberg University, Tiffin, Ohio; [7]Bowling Green State University, Bowling Green, Ohio; [8]Global Quality Corp., Cincinnati, Ohio

In February of 2017, Cleveland Water Alliance (CWA) and DigitalC teamed up to create Erie Hack, a competition that challenged Lake Erie communities to Innovate the Lake. CWA and DigitalC worked with regional partners to activate the economic potential of Lake Erie, providing continuous support

and $100,000 in prizes to over 200 entrepreneurs in the US and Canada as they tackled Lake Erie's key challenges with next-generation solutions.

Many Erie Hackers focused on harmful algal blooms, the annual ecological disaster that threatens an economic impact of $1.3 billion over the next 30 years, by envisioning an Internet of Water: a network of nanosensors and unmanned vehicles, built on underwater telemetry and intelligent analytics. As the competition came to a close, tech, utility, and community leaders came to understand the significance of this vision.

The coalition defined a forward-thinking vision for a Smart Lake Erie. They see that the urgency around algae offers a unique opportunity to deliver unparalleled value to our region's economy and ecology. We need an intelligent monitoring system to help our utilities keep people safe and allow Ohio, Michigan, and Ontario to benchmark and optimize their efforts to reduce nutrient pollution. But, such a system also has the potential to integrate and interpret a broad range of data parameters that could impact a host of legacy and emerging challenges. Our coalition understands that a Smart Lake Erie would serve as a platform for the transformation of data into actionable strategies that leverage water resources into a regional development engine.

Web Interoperability Services with GIS for Global Environmental Monitoring Data Management and Sharing

Frank Schlaeger[1] and Jens Proche[2]
[1]KISTERS AG, Aachen, Germany; [2]KISTERS North America, Roseville, California

The United Nations Global Environmental Monitoring System (GEMS) Water Program is dedicated to providing environmental water quality data (sample results and continuously measured data) of the highest quality, integrity, accessibility and interoperability. This data is provided to the public via the GEMStat website to be used in water assessments and capacity building initiatives. The water quality data currently includes more than 3,000 stations, over 100 parameters, almost four million sample records and is submitted to GEMStat by national focal points of governmental agencies.

In March 2014 the hosting of the GEMStat component was taken over by the German Federal Institute of Hydrology (FIH). The FIH completely redesigned the data storage and management component as well as the representation of data, including the data download portal.

The data storage, management and analysis system will be replaced by a custom off the shelf software with a water quality module. This module was specifically designed to manage, validate and analyse discrete sampling data along with continuously measured real time sensor data. As the water quality module is fully integrated into the system it takes advantage of features such as flexible data structuring, powerful calculations, scripting and graphing functionalities.

The new Web Interoperability Solution will provide environmental monitoring data to the public and allow specialists to easily download the data as required. The solution is a single framework for multiple web service types and serves several data sources at one time such as HTTP GET/POST KVP services (SOS1&2) and SOAP (WaterOneFlow, SOS2). The web service supports user authentication and authorization for members to view and download their data but restricts guest users from accessing directly to ensure data security. In addition to powerful web services, the solution provides time series data for specific web widgets such as creating dynamic time series graphs or displaying descriptive station metadata. The GEMS portal will be set up by applying this functionality and overlaying with GIS mapping capabilities.

The project for redesigning the new GEMStat portal started in September 2015.

Open-Source Spectrometry for Collective Monitoring of Nutrients

Jiansheng Feng, Kelly Siman, Banafsheh Khakipoor, Adam Smith, and Hunter King
University of Akron, Akron, Ohio

We present a cellphone-camera-based spectrometer for measuring phosphorus and nitrogen concentrations in water. The combined hardware/software system is designed to meet the following goals: 1) easy to make with standard makerspace equipment and requires only low-cost, readily available materials, such that it can be affordable/accessible in many schools, makerspaces, or fablabs; 2) be simple and user friendly, such as to function as a teaching tool in K–12 water-related lesson plans and in public parks; 3) produces accurate results comparable to commercial colorimeters or spectrometers; 4) allows simple aggregation of resulting data, which is shared with the users. The intent is to provide a much-needed supplementary data set for nutrient loading from local sources along the watershed, by local inhabitants, while promoting a tangible appreciation of water-related issues in young people.

Telling the Story of Your Lake with Online Maps

Shane Bradt
University of New Hampshire, Durham, New Hampshire

The scientific, volunteer and lake management communities have historically put a great deal of time and money into collecting and analyzing data about lake characteristics. In spite of these vast efforts, a relatively small amount of time has been dedicated to finding compelling ways to present this information to the wide range stakeholders involved with and affected by lake issues. While standard graphs and tables in PDF reports and PowerPoint presentations may communicate information effectively to select group, a far wider audience would be more responsive to stories, images, videos and maps that they can interact with on their own terms.

Online mapping offers the promise of a location-based, engaging method for sharing both data and multimedia in ways not possible a few short years ago. Several types of approaches to online mapping (*e.g.*, Esri Story Maps) have dramatically expanded the ability of people to present information in a compelling online format for free (or nearly so) without any need for coding knowledge. In addition to being able to share information, these tools can also allow people to contribute data

and ideas to lake groups, potentially adding new methods for engaging stakeholders and the public. This presentation will cover ways in which online mapping can be used by scientists, volunteer groups and lake managers to share data and stories about their lakes.

Session E4: Ecological Engineering of Sustainable Landscapes to Protect Downstream Aquatic Ecosystems

10:30 am – 12:00 pm | West Meeting Room 264

The Business of Wetlaculture – Seeking Viable Business Models for Landscape-Scale Nutrient Capture

Sam Miller[1] and William J. Mitsch[2]

[1]Mendoza College of Business, University of Notre Dame, Notre Dame, Indiana; [2]Everglades Wetland Research Park, Florida Gulf Coast University, Naples, Florida

Nutrient runoff is a growing challenge and as the planet's farmers seek to feed a hungry world, the challenge is likely to intensify. The wetlaculture concept seeks to utilize wetlands in field rotation to capture and recycle nutrients at scale – an alternative that is currently being scientifically tested. Opportunities and obstacles with regard to development of business models that can create a share economic incentive to drive adoption of landscape-scale nutrient capture to address nutrient runoff issues in the Great Lakes, Florida Everglades, and elsewhere will be presented here. The wetlaculture concept includes savings farmers can realize via a reduced need to apply expensive nutrients, public sector incentives to remove acreage from active production (*e.g.*, CRP), and other public programs such as conservation easements, wetland reserve program, water quality trading, and carbon sequestration credit programs as economic incentives. Two primary challenges exist in the economic viability of landscape scale wetland systems for nutrient capture. First is the issue of timing. Agribusiness seeks to accelerate crop cycles and output and wetland systems process nutrients more slowly than this sector requires. Mesocosm experiments can quantify x years the site needs to be a wetland for y years as a productive agriculture or horticulture field. Secondly, many of the downstream costs and impacts are externalized – *i.e.*, not included in the economic value chain of the agricultural production system. Effected stakeholders such as tourism and municipal water quality managers face increasing costs of mitigating algal blooms that result from upstream nutrient runoff.

Feasibility of Bundling Conservation Credits for Water Quality Trading in the Blanchard Watershed of Lake Erie

Yanting Guo[1] and Richard Moore[2]

[1]University of Findlay, Findlay, Ohio; [2]The Ohio State University, Columbus, Ohio

Bundling conservation credits or "credit stacking" is a concept used in selling ecosystem credits where two or more spatially overlapping conservation practices are paid for their separate environmental service. The use of bundling credits has been pioneered in the water quality trading arena. Stacking has the potential to create incentives for landowners to increase ecological value and economic benefit with multiple kinds of credits at the same time in the same location with a reduction of paperwork on the farmer's end. Stacking allows credit providers to lower the risk of selling only one type of credit. For example, major weather events might lower the ecological functioning of a particular conservation measure making it fail to produce one type of credit, while it still might produce other types of credits. Stacking may also be useful for financing the best conservation practice when that practice is ecologically sound but cost prohibitive. A drop-off/pick-up survey of 96 farmers in the Blanchard Watershed located in the Maumee Basin of Lake Erie was conducted in 2016 to 2017 with the goal of finding out if farmers preferred bundling conservation credits as an "All-in-One" bundle such as phosphorus, nitrogen, carbon, stream temperature, or biodiversity together rather than as separate commodities. The survey found that 70.8% of the respondents preferred the All-in-One model, 16.7% preferred the more commonly seen phosphorus trading, and 12.5% preferred trading nitrogen or temperature or biodiversity credits alone.

Session E5: Phoslock

10:30 am – 12:00 pm | South Meeting Rooms 237–238

The Use of Phoslock® as a Maintenance Measure to Control Cyanobacteria in a Large Brazilian Urban Lake Subjected to High Organic Load

Tiago Finkler Ferreira[1], Rafael Schmitt[1], Said Yasseri[2], Patrick van Goethem[3], and Nigel Traill[3]

[1]Hidroscience Consultoria e Restauração Ambiental, Porto Alegre, Brazil; [2]Institut Dr. Nowak GmbH & Co., Ottersberg, Germany; [3]Phoslock Europe GmbH, Zug, Switzerland

Lake Pampulha is an urban lake located in Belo Horizonte state, Minas Gerais, Brazil which has undergone intense eutrophication since the 1970s due to the constant input of organic loads from the main tributaries. The aim of this project was to restore the water quality of the Lake and control cyanobacteria using the lanthanum-modified bentonite clay (Phoslock®). A total dose of approximately 1000 tons of the product was applied to reduce internal phosphorus load from the sediment and external input from the catchment over 2016 and 2017. The total dose was divided into monthly applications due to the financial chronogram imposed by the contractor, the Municipality of Belo Horizonte. The treatment resulted in a significant reduction (> 94%) in total phosphorus concentrations which consequently led to a reduction of 92% in chlorophyll and 85% in cyanobacterial density. With such results, the aim of the project was achieved and the classification of the lake according to Brazilian legislation for surface waters (CONAMA 357/2005) was upgraded. The trophic status of the lake improved from hypereutrophic to mesotrophic. Additionally, positive changes in the phytoplankton and zooplankton community were also observed, with an increase in the abundance of Chlorophyceae and Bacillariophyceae. As a result of these changes and the increase in Secchi depth (0.4 to 2 m), *Daphnia* sp were observed in the lake for the first time in decades. The success of the treatment confirms the efficiency

of Phoslock® as a maintenance measure to reduce phosphorus concentrations, thereby controlling cyanobacteria, even in systems subjected to input of continuous and high organic loads.

Combining Lake Restoration Techniques: Overview of Different Treatment Methods Used in Combination with Lanthanum Modified Bentonite (LMB)

Patrick Van Goethem
Phoslock Europe GmbH, Antwerp, Belgium

Phosphorus is an important nutrient for all living organisms in the aquatic food web and its concentration is a critical component in the determination of the trophic level of a water body. In fresh water systems it is often the limiting nutrient making it the primary focus of many water-quality management techniques. One of these techniques is the sequestration of water and sediment phosphate by Lanthanum Modified Bentonite (LMB). Though LMB is a tool that can be used on its own, there are situations where the use of LMB can be combined with other water-quality management techniques in order to achieve a better and/or quicker improvement of a lake.

We provide an overview of the different techniques which have been combined with the use of LMB in recent past years in order to optimise or accelerate efficiency. We also discuss the reasons for choosing a particular combination and assess the efficiency of each method based on whole lake applications.

Session F1: Fish Ecology and Fisheries Management

1:30 pm – 3:00 pm | West Meeting Rooms 260–261

Developing a Conservation Strategy for Riverine Fish Habitat in Oxbow Lakes Along the Lower Wabash and White Rivers in Indiana

Cassie Hauswald[1] and Brad Smith[2]
[1]The Nature Conservancy, Laconia, Indiana; [2]The Nature Conservancy, Velpen, Indiana

Oxbow lakes are an important habitat type found along Indiana's major rivers in southwest Indiana. They are an integral part of a river's ecology. Many species of riverine fish use oxbows to reproduce or rear young. Oxbow lakes are also home to many species of rare plants, and they provide wintering and nesting habitat for waterfowl and songbirds.

Despite the ecological importance of oxbow lakes, little is known about their overall health. As a result, there have been no conservation strategies developed around this important habitat-type in Indiana. Oxbow lakes face many threats, including levees, ditching and field tiling within the lake basins, agricultural runoff, and fragmentation of surrounding woodlands.

In addition to these threats, changes in land use and hydrology in the age of European colonization have dramatically altered rates of succession in these habitats. This raises the question of the sustainability of function in the face of high sedimentation and altered flood regimes.

To establish a baseline of data and develop conservation strategies around these lakes, we completed an initial ranking process via GIS, followed by an on-the-ground sampling effort in 2017 including monthly water sampling and in 2018 fish sampling.

We will share our research results to date and discuss the challenges of developing a conservation strategy for a dynamic and large-scale habitat like oxbow lakes along the lower Wabash River.

Reduced Oxythermal Habitat in a Two-Story Fishery: Implications for Phosphorus Management in a Northern Wisconsin Lake

Dendy Lofton[1], Hans Holmberg[1], Gary Pulford[2], and Dan Tyrolt[3]
[1]LimnoTech, Oakdale, Minnesota; [2]Courte Oreilles Lake Assocation, Hayward, Wisconsin; [3]Lac Courte Oreilles Conservation District, Hayward, Wisconsin

Lac Courte Oreilles (LCO) is a deep, 5,039-acre drainage lake in Sawyer County, Wisconsin with multiple bays and basins that support a highly valued two-story fishery. Most of the lake is classified as oligotrophic except for shallow Musky Bay, which has been characterized by eutrophic conditions as a result of elevated phosphorus loading from adjacent cranberry bogs. Recreational use of Musky Bay is impaired due to excessive aquatic plant growth and the presence of dense algal mats, as well as curly leaf pondweed. Musky Bay is a primary spawning area for muskellunge, which are currently declining in numbers likely due to poor habitat conditions and low dissolved oxygen (DO) levels in the bay. In addition, LCO is one of five inland lakes in Wisconsin that support both cisco and whitefish, which rely on optimal oxythermal conditions. Despite attainment of the current total phosphorus (TP) criteria in LCO (40 µg/L in Musky Bay; 15 µg/L elsewhere in the lake), a biologic impairment exists in the lake due to depleted DO levels in the hypolimnion, and warmer waters in the epilimnion, resulting in reduced oxythermal habitat for cisco and whitefish. Recent monitoring data shows that oxythermal habitat is reduced to a very narrow layer for these sensitive coldwater fishes in three major basins. This presentation will discuss long-term trends in TP, numeric characterization of observed DO and temperature data as an indicator of declining oxythermal habitat, and ongoing management efforts to reduce TP loading and restore musky habitat in LCO.

Influence of Fisheries Management on Limnological Characteristics of Three Missouri Reservoirs

John R. Jones and Daniel V. Obrecht
School of Natural Resources, University of Missouri, Columbia, Missouri

Dramatic fluctuations in nutrients, algal chlorophyll and suspended solids were documented over decades in three Missouri impoundments in response to basin-specific

management practices to control turbidity with shoreline stabilization and aquatic vegetation with grass carp. Management was to benefit sport fisheries. Excessive vegetation in Little Dixie Lake was virtually eliminated after stocking grass carp and mineral turbidity increased (68%). Rock and water willow was used to stabilize the shoreline; mineral turbidity dropped by half and algal chlorophyll tripled, despite a decrease in total phosphorus. These changes reflect increased pelagic production. In Carl DiSalvo Lake, macrophyte removal by grass carp and herbicides triggered an alternative plankton state with increases of 3-fold in total phosphorus, 4-fold in total nitrogen, 20-fold in chlorophyll and a 5-fold decline in Secchi depth. In contrast, water willow was planted along the shoreline of Towell Lake to address mineral turbidity and within a decade, Eurasian watermilfoil covered some 70% of the surface area. Grass carp were added and currently coverage is some 30% of surface area. Between the period of turbidity and watermilfoil dominance, there were declines in both phosphorus (35%) and mineral turbidity (60%) and concurrent increase in Secchi depth (50%). Such management practices are applied statewide to benefit sport fisheries, but with less apparent changes in water quality and switches in alternative states. Such practices contribute to residual variation in cross-system analyses of nutrients relative to land cover and hydrology and could mask the benefits of best management efforts in the watershed.

Using Baited Box Nets to Remove Common Carp to Improve Water Quality in Shallow Lakes

Jordan Wein[1], Przemek Bajer[2], and Aaron Claus[1]
[1]Carp Solutions, Saint Paul, Minnesota; [2]University of Minnesota, Saint Paul, Minnesota

Common carp are present in many shallow lakes across North America and can have significant negative impacts on nutrient and water quality parameters when in large numbers. Reducing common carp biomass has been shown to increase water clarity and aquatic vegetation as well as decrease phosphorus and chlorophyll levels. Although research shows that lakes can be restored by managing carp, implementation methods have been severely hindered by lack of effective removal techniques. Traditional methods such as lake drawdowns, poisoning, and commercial seining are often ineffective, harmful to native species, cost-prohibitive, and/or rely on a few specialized contractors that are difficult to secure. An innovative method has addressed this need via baiting and trapping using custom "box net" traps. This approach is consistent with scientific findings that common carp can be trained to aggregate in specific locations using corn as bait. The chief advantage of stationary box nets is that carp can be lured into them and effectively removed, even in lakes with debris on the bottom or where carp do not form natural aggregations. Further, baiting is simple enough that citizens can be trained to administer it, increasing the scalability and affordability of this strategy. Carp Solutions conducted proof-of-concept experiments in 4 Minnesota lakes between 7 and 120 hectares in 2017 which showed that 20–50% of carp were removed from each lake using only 1–4 nets, with no non-target impacts. Managing carp can be a great challenge, but the potential benefits are multi-faceted and box netting could be one solution.

Session F2: Lake Management and Restoration

1:30 pm – 3:00 pm | West Meeting Room 262

Sediment Sampling to Assist in Evaluating Potential Reservoir Management Methods

Kelly DiNatale[1], Alex Horne[2], Chris Newton[1], and Andrea Terry[3]
[1]DiNatale Water Consultants, Boulder, Colorado; [2]Alex Horne Associates, El Cerrito, California; [3]Rivanna Water and Sewer Authority, Charlottesville, Virginia

The Rivanna Water and Sewer Authority (RWSA) is a wholesale water utility that owns and operates five reservoirs that hold drinking water supply for the City of Charlottesville and Albemarle County, Virginia. The reservoirs have experienced problems with algae blooms, which have historically been managed by the application of copper-based algaecides. Historical water quality data was limited except for the late 1970s through early 1980s and RWSA began a monitoring program in 2015 to develop a database of water quality data.

RWSA was evaluating potential reservoir and watershed management methods to improve water quality. As part of the evaluation, RWSA was seeking insight to the following questions and the associated management implications:

- Did the application of copper-based algaecides result in copper accumulation in the reservoir sediments? If there was copper accumulation that could be traced to algaecide applications, was the accumulation at concentrations that might exceed regulatory levels or otherwise trigger concerns?
- Did the diversion of effluent in one watershed in the late 1980s result in improvement in water quality? If it could be demonstrated that the reduction of inflowing nutrients results in improved water quality, it might be possible to improve water quality through reduction of nutrients within the watershed through a variety of management methods.
- Is there a significant internal nutrient flux from the reservoir sediments that should be addressed? If there was significant internal loading from accumulated reservoir sediments, management methods such as alum treatment, hypolimnetic aeration/oxygenation or dredging.

To further inform management decisions, dredge and core sediment samples were collected and analyzed in two reservoirs. Copper accumulation was detected, but at below regulatory levels. Additional watershed sampling suggested that the copper increases were likely attributable to algaecide applications. Dating and analysis of sediments showed a significant decrease in nutrients and blue-green algal pigments approximately coincident with the wastewater diversion. Nutrient fluxes were less than anticipated given the nutrient concentrations in the sediments and the length of hypolimnetic anoxia.

A Method of Reducing Septic System Impact to Lakes

Paul Sutphen
Clear Lake Technology, Branchville, New Jersey

Lakes are affected by what happens in their watershed. Rural lake communities, for the most part, are served by on-site septic systems. The performance of these systems is highly dependent on a host of factors ranging from location, age, design, soil characteristics and proximity to ground water to the lake. Phosphorus from septic systems is often the limiting factor that controls the level of eutrophication and potential for harmful algae blooms.

Most household products no longer contain phosphorus. The main source of phosphorus is human waste. The daily production of phosphorus is about 1–1.5 grams per person. A four-person household can produce over 2 kg. of phosphorus annually. Septic systems are not perfect treatment systems and are reported to be a major cause of nutrient loading. The threat that phosphorus loading poses to lake water quality and health became the motivation behind the development of this waste water conditioning phosphorus removal system described herein.

This system developed over 4 years, has proven to eliminate over 90% of the phosphorus and coliform that would normally be discharged to a disposal field. Nominal pump out frequency is 2 to 3 years depending on septic tank size and design. The components of the conditioning system are of proven design and are currently available. No disturbance to the existing in-ground septic system is required. A managed service is needed.

Lake communities that adopt the use of this system will improve their lake's water quality and may prevent the need for community sewers.

A Tale of Two Watersheds: Addressing Challenges for Funding Restoration

Clell J. Ford
Beaver Watershed Alliance, Springdale, Arkansas

All resource managers face the challenge of acquiring funding and energizing the public in order to protect and restore regional water quality. This often means addressing the rather blunt question of "Who cares?" Garnering public and government support for source water protection is a common first step for all watersheds. Two comparable systems, Lake Istokpoga (112 km^2 lake, 1554 km^2 watershed), and Beaver Lake (114 km^2 lake, 3087 km^2 watershed), have US Army Corps of Engineers regulation schedules, are important sources of water for their respective regions, and have similar success in engaging stakeholders. However, success in funding restoration in these two regions differs greatly. Despite the status of the Istokpoga watershed as the largest source of permitted consumptive use surface water in Florida's Kissimmee Valley, managers have struggled to identify sustainable funding for lake and watershed restoration. In contrast, the Beaver Lake watershed, which is situated in the headwaters in the Ozarks and drinking water source for more than one in seven Arkansans has sustainable funding for source water protection and watershed management activities. This talk will highlight the funding opportunities, restoration, and protection challenges faced by water resource managers for both of these watersheds. It will also shed light on future innovations in source water protection funding by exploring the possible expansion of the EPA's clean water state revolving funds.

Reservoir Modeling to Enhance Temperature Compliance near a Power Plant in the Tennessee River System

Rich Wildman[1], Colleen Montgomery[2], Jessica Brazille[2], Jacob Krall[1], and Rob Annear[1]
[1]Geosyntec Consultants, Portland, Oregon; [2]Tennessee Valley Authority, Knoxville, Tennessee

The Tennessee Valley Authority (TVA) is responsible for managing temperature in the Tennessee River in accordance with water quality discharge permits issued to its thermal power plants. These plants withdraw cooling water from Tennessee River reservoirs and return it at increased temperatures. Discharge permits impose two regulations: 1) the absolute temperature of surface water may not exceed a specific value and 2) the temperature increase of surface water from upstream to downstream caused by a power plant may not exceed specific values. When the absolute temperature or temperature rise increases, the TVA must either activate its cooling towers or curtail power generation to ensure compliance with its permits. Both actions incur great financial cost. In this project, we sought to determine the effect of flow scenarios in a Tennessee River reservoir on surface water temperature of the reservoir at the permit compliance locations. We used CE-QUAL-W2, a two-dimensional hydrodynamic and water quality model, to evaluate a set of reservoir operation scenarios that attempt to minimize temperature increases past the power plant. Model results indicate that moderately-high summertime flow events disrupt thermal stratification and thus cool the surface water. However, this effect is greater at the upstream compliance location, and thus destratification events increase the temperature rise due to the power plant. Reduced flow events lead to warmer temperatures across the reservoir. Few scenarios were able to overcome the effects of high-wind events that de-stratify the water column upstream but not downstream and thus confound efforts to minimize temperature increase.

Session F3: HABs – Prediction and Monitoring

1:30 pm – 3:00 pm | West Meeting Room 263

Building a Financially Sustainable Early-Warning System for Harmful Algae

Max Herzog[1], Bryan Stubbs[1], Kelli Paige[2], Becky Pearson[2], John Bratton[3], Ed Verhamme[3], Tom Johengen[4], and Greg Doucette[4]
[1]Cleveland Water Alliance, Cleveland, Ohio; [2]Great Lakes Observing System, Ann Arbor, Michigan; [3]LimnoTech, Ann Arbor, Michigan; [4]NOAA GLERL, Ann Arbor, Michigan

Harmful Algal Blooms (HABs) that occur in Lake Erie are a persistent annual problem that has threatened human health, economic stability, and ecosystem integrity in Lake Erie. Multiple federal, state, and academic groups currently monitor the western basin of Lake Erie for cyanobacterial abundance and toxicity.

However, these efforts are only minimally coordinated, and samples are collected in various ways, making the comparison and integration of data difficult.

A public-private partnership comprised of Great Lakes Observing System (GLOS), Great Lakes Environmental Research Laboratory (GLERL), Cleveland Water Alliance (CWA), and LimnoTech has been awarded a three-year NOAA Ocean Technology Transfer grant to implement and commercialize an integrated monitoring solution to this challenge. The team will leverage the current real-time observing network for HABs, to drive key technologies through the transitional stages between research and full operations in order to ensure that they are sufficiently mature for long-term operations.

Additionally, the project engages with stakeholder input and collaboration with the goal of creating and stabilizing a reliable funding and operations plan for a Lake Erie Harmful Algal Blooms Data Management and Communication support structure for 1) an existing operational real-time sensor network whose components are owned and operated by Ohio drinking water utilities and their contractors, and 2) a related research sampling and monitoring network in Lake Erie. This will allow stakeholders optimized access to critical monitoring data to help inform management decisions that are affected by the presence of HABs, as well as making this information available to the general public.

Monitoring Cyanobacteria in Mixed Algal Populations in an Effort to Predict the Onset of CyanoHABs

Lawrence Younan
Turner Designs, San Jose, California

Global occurrence of CyanoHABs is increasing at an alarming rate sparking a need for development of new methods and tools to rapidly quantify, monitor, and mitigate bloom events. Countless annual timelines have been recorded showing increased bloom activity at a certain time of the year, "hot" season, followed by relaxation period. During a "hot" season, when bloom activity is expected to peak, we're preparing for sampling and analysis in an effort to better characterize the factors leading to the onset of HABs. During the relaxation period there may also be short lived HAB events stemming from changes such as increased anthropogenic input or anomalous heat spikes. These off-peak bloom events may offer better information for determining the driving factors behind HABs, but are hard to catch using *in situ* fluorometers that specifically monitor cyanobacterial marker pigments such as phycocyanin (PC), which only provide a partial answer to the question, "Is a HAB fast approaching?" A more detailed approach using high frequency, field-ready tools such as the CyanoFluor or PhytoFind, which use pigment ratios, allows us to rapidly monitor cyanobacteria populations WITHIN total algal populations providing information which can be used to predict the onset of HABs and offering valuable data for building predictive models. This is the best approach to help further our understanding of why HABs occur.

Working Towards a Forecast of Lake Erie Cyanobacterial Bloom Toxicity

Justin Chaffin[1], John Bratton[2], Tom Bridgeman[3], Tim Davis[4], Greg Dick[5], Kevin Meyer[5], Ed Verhamme[2], Judy Westrick[6], and Pengfei Xue[7]
[1]Ohio State University, Put in Bay, Ohio; [2]LimnoTech, Ann Arbor, Michigan; [3]University of Toledo, Toledo, Ohio; [4]Bowling Green State University, Bowling Green, Ohio; [5]University of Michigan, Ann Arbor, Michigan; [6]Wayne State University, Detroit Michigan; [7]Michigan Technological University, Houghton, Michigan

Lake Erie has been plagued by *Mycrocystis* blooms since the late 1990s. In recent years, a seasonal bloom forecast has been issued in early July based on the spring phosphorus load from the Maumee River. Although bloom size and location can be reasonably well forecasted, questions remain about the controls and predictability of microcystins (MC) concentrations in blooms. One complexity in field studies has been the coexistence of toxic and non-toxic strains of *Mycrocystis*. The factors influencing the dynamics of toxic and non-toxic strains within blooms are only beginning to be understood, but they may be at the point where reasonable predictions of changes in MC concentrations could be possible. While phosphorus has a clear role in bloom dynamics, nitrogen may also be important in the occurrence and biomass of cyanobacteria and the toxicity within the blooms. Other factors, such as light intensity and temperature, may also interact with nitrogen to impact MC production. This presentation will present 1) historical (since 2014) MC and cyanobacterial biomass correlations from 4758 samples collected between June and October in the western basin, 2) numerical models of ecological and physical processes to develop hindcasting, nowcasting, and forecasting capabilities, and 3) field and laboratory experiments that show the influence of nitrogen, light, and temperature on MC production and biodegradation rates. We are working with NOAA to incorporate the results of this project into forecasting operational systems.

Lake Champlain's Cost-effective and Successful Cyanobacteria Monitoring Program

Angela Shambaugh[1], Bridget O'Brien[2], Lori Fisher[3], and Heather Campbell[1]
[1]Vermont Department of Environmental Conservation, Montpelier, Vermont; [2]Vermont Department of Health, Burlington, Vermont; [3]Lake Champlain Committee, Burlington, Vermont

Lake Champlain lies between Vermont, New York and the province of Quebec in Canada. In 1999, the lake experienced its first known toxic cyanobacteria bloom when two dogs died after ingesting cyanobacteria. Nuisance blooms had been documented in parts of the lake since the late 1970s, but there was limited information regarding cyanobacteria composition or seasonal dynamics at the time. Entities already active on Champlain rapidly formed a partnership to monitor cyanobacteria conditions during the summer recreation period. This strong partnership has grown over the last 15 years, utilizing qualitative and quantitative data collected by citizen volunteers and state staff.

The monitoring approach is based on visual cues that can be used by anyone anywhere to evaluate cyanobacteria condition and impact on recreational activities. Selected stations also provide quantitative data on cyanotoxins and phytoplankton densities. Weekly reports provided by trained observers between

mid-June and late September are shared via an online tracking map and weekly email updates. Rapid communication of bloom conditions to state and local health officials in each jurisdiction facilitates response at the local level according to their established procedures. Together, this system has become a cost-effective and successful approach to monitor cyanobacteria on a very large, multijurisdictional lake.

Session F4: Invasive Species

1:30 pm – 3:00 pm | West Meeting Room 264

The Effects of Invasive Species in Kentucky Lake (USA) as Documented by Long-Term Monitoring

David White[1], Susan Hendricks[1], and Bommanna Loganathan[2]
[1]Hancock Biological Station, Murray State University, Murray, Kentucky; [2]Department of Chemistry, Murray State University, Murray, Kentucky

While limited populations of silver carp *(Hypophthalmichthys molitrix)* and zebra mussels *(Dreissena polymorpha)* have existed for more than 25 years in Kentucky Lake (Tennessee River), both species had not become truly invasive until quite recently. Our understanding of the mechanisms behind silver carp's explosive growth are inadequate at this time. Zebra mussels became "invasive" in 2017 and can be associated with changes in dissolved calcium levels between 2012 and 2017 that now exceed the 21–23 mg per liter threshold for their establishment. Both invasives are planktivorous and appear to be linked with changes in Secchi depth, turbidity, plankton community structure, alkalinity, and primary productivity as shown by the 30-year Kentucky Lake Long-Monitoring Program database. Secchi depth (m) has slowly increased since 1988 from about 1 m to 1.5 m with several readings well over 3 m in recent years. Turbidity has slowly decreased from 15 NTUs in 1988 to averages now around 4 NTUs. Commensurate with turbidity, there have been decreases in zooplankton, phytoplankton, and primary production, but surprisingly, levels of chlorophyll *a* have remained fairly constant. Changing lake conditions have trophic level implications for native planktivores, especially freshwater mussels, shad, paddlefish, and larval stages of most fish species. As the monitoring program continues, we should be able to better document long-term changes in food web dynamics linked to these and other invasive species.

Constraints on Curly-Leaf: An Evaluation of Curly-Leaf Pondweed Biology and Management Through Analysis of Monitoring Data from Across Organizations

★ **Michael R. Verhoeven, Daniel J. Larkin, and Raymond M. Newman**
University of Minnesota Department of Fisheries, Wildlife and Conservation Biology & Minnesota Aquatic Invasive Species Research Center, St. Paul, Minnesota

Curly-leaf pondweed *(Potamogeton crispus)* is one of the most widespread and problematic invasive aquatic plants in the Great Lakes region. Despite decades of research and treatment efforts, there is still uncertainty about best practices for treating curly-leaf pondweed and the influence of environmental factors, such as trophic state and winter conditions, on curly-leaf populations. To address these gaps, we synthesized and analyzed data from 252 point-intercept surveys of 51 lakes collected from 2006–2015. Nineteen lakes had data for years treated with herbicide (65 treatment lake-years) and 41 lakes had data for untreated years (116 untreated lake-years). We used generalized linear mixed models to estimate the influence of environmental drivers and herbicidal treatments on curly-leaf lake-level distribution (frequency of occurrence) and abundance (relative rake density). We found that greater winter snow cover, water clarity, and herbicide treatment were associated with reductions in lake-wide distribution of curly-leaf pondweed. We parsed the effects of herbicides based on three temporal windows and found that curly-leaf pondweed distribution was reduced within the year of treatment, the year following treatment, and by cumulative years of treatment. In contrast, curly-leaf pondweed abundance was not affected by environmental variables, and only by a within-year effect of herbicide treatment. Our results show that increasing long-term consistency of herbicide-based management may allow for lower annual management inputs, and that environmental conditions should be considered in management planning. This project highlights the power of combining monitoring data from across organizations to support collective learning and adaptive management.

Wisconsin's Strategy for Prevention of Aquatic Hitchhikers

Susan Graham and Amanda Smith
Wisconsin Department of Natural Resources, Madison, Wisconsin

Aquatic invasive species, otherwise known as AIS, are non-native species that can take over, spread primarily by humans, and negatively impact recreation, the economy, and our native ecosystems. Given the scale of the problem and the threat, this presentation will describe what Wisconsin is doing, how we encourage citizens to partner with scientists, and what success has looked like here. Wisconsin has a comprehensive rule called NR-40 that classifies species that are prohibited, restricted, or not a concern, and guides regulations based on risks. In addition to containment and control, we employ a multi-faceted approach to prevent the introduction and spread of AIS. For the Wisconsin DNR, preventing the spread of invasive species relies on a social science understanding of human behavior.

Deep in the Weeds of Aquatic Plant Management in New Jersey's Delaware and Raritan Canal

Chris J. Doyle[1], Jon Gosselin[2], Heather Desko[3], Emily R. Mayer^{1,4}, and Mark A. Heilman[5]
[1]SOLitude Lake Management, Washington, New Jersey; [2]SePRO Corporation, Manchester, New Hampshire; [3]New Jersey Water Supply Authority, Clinton, New Jersey; [4]University of Florida, Gainesville, Florida; [5]SePRO Corporation, Carmel, Indiana

Dense aquatic vegetation growth affects the ability of New Jersey's Delaware and Raritan Canal to transfer 100 Million Gallons of Water a Day (100 MGD) from the Delaware River to meet the demands of drinking water treatment facilities and golf courses on its way to the Raritan River. In 2016, the vegetation was so dense, the New Jersey Water Supply Authority contracted for conventional mechanical raking to reduce submersed aquatic

plant growth, only to discover several miles of *Hydrilla verticillata* growth. This finding led to the development of an Aquatic Plant Management Plan, 60 miles of canal submersed aquatic vegetation mapping, a low-dose herbicide application, and an intensive monitoring plan to manage the infestation. This presentation will cover the treatment, mapping, and monitoring response that the New Jersey Water Supply Authority initiated in 2017, plus an update on the 2018 continuing efforts.

Session F5: Watershed and Water Management

1:30 pm – 3:00 pm | South Meeting Rooms 237–238

Lake Mauvaise Terre Nutrient and Sediment Reduction Initiative

Jeff Boeckler
Northwater Consulting, Springfield, Illinois

Lake Mauvaise Terre lies within Morgan County, Illinois, has a surface area of approximately 170 acres and serves as a back-up source of drinking water for the City of Jacksonville and surrounding communities. The watershed area for Lake Mauvaise Terre is 21,402 acres, primarily made up of agricultural row crops which are responsible for 70% of the total lake sediment load. Mauvaise Terre is impaired for total suspended solids, total phosphorus, and total nitrogen. A Total Maximum Daily Load (TMDL) plan finalized in 2011 indicated that a substantial reduction in both internal and external loads was required to meet the State's 0.05 mg/L phosphorus standard. Unfortunately, the TMDL lacked specifics on implementation strategies and locations. This prompted the development of a Watershed Implementation Plan with support from the American Farmland Trust and the City of Jacksonville. Using targeted field assessments, modeling, and one-on-one landowner outreach, a series of locations were identified that represented the primary sources of sediment and phosphorus. The City partnered with a selection of landowners and an EPA Section 319 grant application was submitted. The $650,000 grant was approved in 2015 and used for the survey, design, and construction of hundreds of individual Best Management Practices. The initiative achieved a 4.3% reduction in total nitrogen, a 7% reduction in total phosphorus and a 12% reduction in sediment. The presentation will highlight key aspects of the watershed planning process, meaningful pollutant source assessment, landowner negotiations, the grant application, BMP design and construction considerations, and results.

Response of a Reservoir Ecosystem to Changes in Watershed Agriculture Over Two Decades

Michael Vanni, William Renwick, Maria Gonzalez, Patrick Kelly, and Tanner Williamson
Miami University, Oxford, Ohio

We present 24 years of data on the response of eutrophic Acton Lake to changes in watershed agriculture. Over the first decade, the use of conservation tillage increased greatly in the watershed. This led to large decreases in suspended sediment (SS) and P (soluble and particulate) concentrations in inflow streams and decreased (discharge-adjusted) loads of SS and P to the lake. However, during the second decade, stream SS declined at a slower rate, and soluble P actually increased. In contrast, stream nitrate changed little over the first decade, but declined sharply in the second decade. In Acton Lake, phytoplankton biomass increased markedly over the first decade, despite decreased inputs of P from streams. The phytoplankton increase was probably because declining lake SS concentrations alleviated phytoplankton light-limitation, and because of increasing biomass (and hence nutrient excretion rate) of detritivorous fish, specifically gizzard shad. Over the second decade, phytoplankton biomass showed no temporal trend. However, phytoplankton N-limitation became more common, whereas P was usually limiting in the first decade. This shift toward increasing N limitation is associated with declining stream N:P ratios and a greater importance of internal loading from fish excretion, which has relatively low N:P. Our long-term data reveal complex, temporal scale-dependent responses of a reservoir ecosystem to changing watershed agriculture. In addition, our data show that internal nutrient cycling by fish, and reduced light limitation, provide resilience against reversing eutrophication.

Upstream Collaboration and Investment Achieves Downstream Protection

Kate Dunlap
City of Boulder, Public Works, Boulder, Colorado

Barker Reservoir is a primary water supply for the City of Boulder, with storage capacity of up to 11,000 acre-ft. A small wastewater treatment facility (WWTF) with an average flow of 0.14 MGD contributes < 1% of the reservoirs average annual inflows, yet prior to 2013 was responsible for 65% of the total phosphorus (TP) and 40% of the total nitrogen loading. The WWTF was exempt from TP limits due to size, but basic upgrades from the aerated lagoon system were required to achieve ammonia limits in a revised discharge permit.

Seeing the opportunity to invest in the WWTF to protect Barker Reservoir from eutrophication, water treatment challenges, and taste and odor issues, Boulder provided $300,000 in capital funding for WWTF TP removal, and annual financial support ($17,300 adjusted annually for inflation) through 2024.

Since the 2013 WWTF upgrades, effluent TP concentrations have decreased 10-fold resulting in improved reservoir water quality. Average reservoir TP decreased from 19.6 to 12.4 µg/L, and biologically available forms of nutrients have also decreased: ortho-P decreased by 53% and total Kjeldahl nitrogen decreased by 23%. Although not statistically significant, reservoir chlorophyll *a* decreased from 7.7 to 6.9 µg/L. Chlorophyll *a* is a nutrient response variable and reductions may take longer to detect.

Investing in upstream WWTF upgrades improved water quality in the city's primary source water reservoir and has allowed the city to maintain conventional water treatment. Further, the investment has better positioned the upstream community for meeting future nutrient controls.

Changes in Grand Lake St. Marys Watershed: Moving Towards an Improved Understanding of Water Quality Over the Past Decade

Stephen J. Jacquemin
Wright State University - Lake Campus, Celina, Ohio

Grand Lake St Marys (GLSM) is a hypereutrophic lake situated in the primarily agricultural GLSM watershed of northwest Ohio. Over the past decade, numerous surveys have characterized the environmental quality of the lake as highly impaired. Elevated nutrient rich runoff levels coupled with the physical characteristics of the watershed have acted as catalysts for frequent harmful algal blooms resulting in no contact warnings and drinking advisories which have impacted the region environmentally and economically. In 2011, the watershed was officially declared distressed by the state of Ohio. Following this designation, a series of voluntary and obligatory best management practices, conservation initiatives, and rules were implemented in an effort to reduce nutrient loading on a watershed scale. These efforts included constructing wetlands and in-lake littoral areas, increasing the use of filter strips, riparian buffers, cover crops, improving manure management practices, such as transferring manure out of the watershed and increasing covered manure storage, and the implementation and enforcement of policies encompassing the maintenance of nutrient management plans and a watershed wide ban on winter manure application. Since 2011, nitrogen and phosphorus concentrations have greatly declined during the winter months (16–57%) as well as the remainder of the year (12–41%; with exception of spring SRP) during critical medium and high flow loading periods. Despite these impressive declines, however, nutrient levels remain too high. Thus, conservation work in GLSM is ongoing and includes the continued expansion of existing BMPs as well as addition of new wetlands to continue improving water quality region wide.

Session G1: Fish Ecology and Fisheries Management

3:30 pm – 5:00 pm | West Meeting Rooms 260–261

3D Modeling and Prediction of Coolwater Fish Habitat in a Changing Climate

Shahram Missaghi
Water Resources Team, University of Minnesota Extension, Farmington, Minnesota

Climate change impacts the physical, chemical, and biological processes of aquatic ecosystems. Future fish habitat conditions are predicted to change both their temporal and spatial distributions. The ability to predict the fish habitat with fine spatial and temporal resolutions can facilitate and target fish management strategies that can reduce the undesirable impacts of climate change. We investigated the temporal and spatial (both vertical and horizontal) variability of fish habitat dynamics at a fine scale by using a 3D lake water quality model. We implemented a measured historical scenario and two predicted future climate change scenarios developed by applying the change fields to the two measured scenarios; results and the methods used will be presented. Water temperature (T) and dissolved oxygen (DO) were selected as key water quality parameters to evaluate the changes in coolwater fish habitat, where T increased 4 °C and DO decreases 1 mg L^{-1} during the ice-free seasons under the future climate scenarios. The onset of stratification increased 46 days, thermocline depth increased 64%, and the onset of anoxia occurs 4 weeks earlier. For the first time, we will report the 3D changes of T and DO defining fish habitat in a Minnesota lake. The desirable good growth fish habitat was separated for three weeks in July by the lethal fish habitat, leaving the coolwater fish with no potential refuge. The spatial and temporal prediction of stressed or lethal environmental conditions along with forecasting the potential fish refuge areas is essential in water resources and ecological management.

The Feasibility of Restoring Lake Whitefish as an Integral Component of the Cold-water Fish Community in Otsego Lake, New York

★ Samantha Carey[1], Kevin C. Thomas[2], Daniel T. Garrett[2], Brent C. Lehman[2], John R. Foster[2], Mark D. Cornwell[2], Scott Wells[3], and Daniel S. Stich[1]
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Lake Whitefish (LWF), a key component of the cold-water fish fauna of Otsego Lake was decimated by the introduction of Alewife *(Alosa pseudoharengus)* in the 1980s. With the recent collapse of the Alewife in this system, the restoration of the historically important LWF population is now feasible. A collaborative effort to enhance LWF in Otsego Lake is now underway, involving the New York State Department of Environmental Conservation, the State University of New York (SUNY) at Cobleskill, and the SUNY Oneonta Biological Field Station. Project objectives are to 1) document LWF spawning locations and population dynamics, and 2) supplement the population through field spawning, egg rearing and stocking of fry and fingerlings. Electrofishing, trap netting and fry emergence traps identified three spawning locations in the lake. The LWF produced in the Endangered Fish Hatchery at SUNY Cobleskill will help restore an important Otsego Lake fishery and balance the lake's cold-water fish community by enhancing the lake trout forage base.

Session G2: Lake Management Topics

3:30 pm – 5:00 pm | West Meeting Room 262

Hydropower Retrofits at Non-Powered Dams: Trends in Environmental Mitigation

Miles Mobley, Joey Werble, Adam Witt, and Patrick O'Connor
Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee

The United States currently utilizes more than 80,000 non-powered dams (NPDs)—dams that do not produce electricity—to provide a variety of services ranging from water supply to inland navigation. As the United States seeks to increase renewable energy generation, hydroelectric retrofits of NPDs have become an attractive option for two reasons: the use of existing hydraulic

infrastructure lowers the total installed cost of the project, and many of the environmental impacts of development have already been incurred. Many of the NPDs currently slated for development are navigation dams that form pools in navigable waterways, and the protection, enhancement, and mitigation measures and costs associated with such NPD retrofits have not been well established.

This presentation will summarize an analysis of federally required environmental mitigation measures and associated costs from over 70 NPD retrofits licensed by the Federal Energy Regulatory Committee (FERC) within the last 15 years, with an emphasis on riverine NPD development. Measures and costs were gathered from formal environmental assessments, largely reflecting the consensus outcomes of detailed studies and negotiations among project stakeholders. Cataloging the types of mitigation requirements (*e.g.*, aquatic resources, water quality, recreation resources, threatened and endangered species, etc.) by dam purpose (*e.g.*, lock and dam) can provide valuable insight to hydro developers and lake managers who want to investigate the possibility of adding hydroelectric capabilities to existing NPDs.

Kicking the Tires on the New 3D Water Quality Model AEM3D

Keith Pilgrim
Barr Engineering Company, Minneapolis, Minnesota

Given the expense of restoring lakes to a quality acceptable for many uses such as recreation and drinking water, it is becoming more important to better understand lake dynamics and make more accurate predictions of a whole host of water quality parameters, not just phosphorus. For some systems, a three-dimensional model is needed but there are very few that are available. The Aquatic Ecosystem Model (AEM3D), built by Hydronumerics in Australia, is a newly available model based upon the ELCOM-CAEDYM model developed at the University of Western Australia. This presentation shows the results of an AEM3D model that was built for Sweeney Lake in Golden Valley, Minnesota. The purpose of this modeling effort was to evaluate the effect of aeration in Sweeney Lake on phosphorus, phytoplankton, and dissolved oxygen in the lake. Using AEM3D, a comparison was made between the relative effectiveness of alum treatment and aeration.

Continuous Lake Monitoring Buoy – Lessons Learned from the First Year

Kiyoko Yokota and Paul H. Lord
State University of New York College at Oneonta / Biological Field Station, Oneonta, New York

Continuous lake monitoring buoys, or lake data buoys, once mainly developed and used by academic researchers, are gaining popularity within the greater lake management communities, including municipal utility operators and individual lake associations. These buoys log and transmit high-frequency data that reveal previously unnoticed spatial and temporal patterns in physical, chemical and biological processes in lakes and reservoirs. Established commercial vendors are capable of configuring a system that meets specific monitoring needs of a given site; however, the actual deployment method and maintenance needs are highly site specific and need to be carefully planned and executed by the local project managers. We present a case study from Otsego Lake, a glacial mesotrophic lake (maximum depth ≈ 51 m or 168 ft) in Central New York State, where we completed the first cycle of deployment, winterization and re-deployment of our NSF-funded data buoy in 2017–2018 as part of the Global Lake Ecological Observatory Network (GLEON). System configuration processes, initial and recurring cost, data management and analysis will also be covered.

Aquatic Effects Monitoring for the Meliadine Mine

Colleen Prather, Elaine Irving, Suzanne Earle, and Zsolt Kovats
Golder Associates Ltd., Edmonton, Alberta, Canada

The Meliadine Gold Mine is located in the Kivalliq District of Nunavut in Northern Canada, and approximately 25 km north of the community of Rankin Inlet. The Aquatic Effects Monitoring Program (AEMP) is a requirement of the licence to operate the Mine. The AEMP was structured as a comprehensive monitoring program with the overall objective to assess potential mine related effects on water quality, sediment quality, benthic invertebrates, plankton, and fish of Meliadine Lake.

Pre-construction activities were completed at the Mine in 2015 and 2016, and construction activities were initiated in October 2016; discharge of mine generated effluent (the main pathway that can affect the aquatic environment) was initiated in June 2018. The AEMP is an annual monitoring program and data collected in 2015 through 2017 were evaluated to characterize the aquatic environment before effluent discharge. Data collected starting in 2018 through operations (*i.e.*, while the Mine is discharging effluent) will be used to characterize effects to the aquatic environment.

Meliadine Lake is a large lake with a surface area of 107 km^2, a highly convoluted shoreline of 465 km, over 200 islands, and a watershed area of 560 km^2. Development in the watershed is limited to a few cabins, resource exploration, and the Mine.

This presentation will provide details of the integrated aquatic effects study design, a summary of data collected since 2015, ecological interpretations of the data, and next steps in aquatic effects monitoring at this location.

Session G3: HABs

3:30 pm – 5:00 pm | West Meeting Room 263

Influence of Environmental Factors on Off-Flavor Metabolite Production by Bacteria in a Eutrophic Reservoir

★ Nicolas A. Clercin[1,2] and Gregory K. Druschel[1]
[1]Department of Earth Sciences, Indiana University – Purdue University, Indianapolis, Indiana; [2]Center for Earth and Environmental Science (CEES), Indianapolis, Indiana

The community structure of bacterioplankton in a dimictic and eutrophic drinking water supply reservoir was characterized by PCR amplification using the V3 and V4 regions of the 16S rRNA.

Bacterial communities were recovered from different depths (0, 3, 6 and 10 m) within the water column through time (April to October). Meanwhile, the physical properties of the water column were measured *in situ* as well as the water chemistry for major anions and two odorous bacterial metabolites, 2-methylisoborneol (MIB) and geosmin. In average, dominant bacterial groups were Cyanobacteria (36%), Proteobacteria (25%) and Actinobacteria (7%). A cross correlation linked a major peak discharge to highest detections of both MIB and geosmin after a 37-day delay. Geosmin detections were strongly correlated to occurrences of Cyanobacteria (*Planktothrix spp.*, $p < 0.001$) that was growing in the reservoir waters while MIB led to the Actinobacteria (*Streptomyces spp.*, $p < 0.01$). Application of a copper-based algaecide treatment terminated Cyanobacteria and disrupted the geosmin production whereas it was not so effective against Actinobacteria and MIB. A Canonical Correspondence Analysis (CCA) shows that taste-and-odor (T&O)-causing bacteria are more abundant when the water is enriched with nitrogen, temperature cooler and, the water column fully mixed and oxygenated.

Understanding the Effect of Salinity Tolerance on Cyanobacteria Associated with a Harmful Algal Bloom in Lake Okeechobee, Florida

Barry Rosen[1], Keith Loftin[2], Jennifer Graham[2], Katherine Stahlhut[1], James Riley[3], Brett Johnston[1], and Sarena Senegal[2]
[1]US Geological Survey, Orlando, Florida; [2]US Geological Survey, Lawrence, Kansas; [3]US Army Corps of Engineers, Jacksonville, Florida

In an effort to simulate the survival of cyanobacteria as they are transported from Lake Okeechobee to the estuarine habitats that receive waters from the lake, a bioassay encompassing a range of salinities was performed. An overall decline in cyanobacteria health in salinity treatments greater than 18 practical salinity units (psu) was indicated by loss of cell membrane integrity based on SYTOX® Green staining, but this loss varied by the kind of cyanobacteria present. *Microcystis aeruginosa* was tolerant of salinities up to 18 psu; however, higher salinities caused leaking of microcystin from the cells. *Dolichospermum circinale*, another common bloom-former in this system, did not tolerate salinities greater than 7.5 psu. Stimulation of mucilage production was observed and is likely a mechanism used by both species to protect organism viability. At 7.5 psu, and to some extent at 10 psu, microcystin increased relative to chlorophyll *a*, providing some evidence of biosynthesis when *M. aeruginosa* is stressed at these salinities. At 15 psu or greater, the particulate microcystin concentration relative to chlorophyll *a* is diminished, although additional research would be needed to determine the exact effect of salinity on this relation.

Potential Linkage Between Zebra Mussel Establishment, Cyanobacterial Community Composition and Microcystin Levels in United States Lakes

Feng Zhang[1], Song Liang[2,3], Ozeas Costa[4] and Jiyoung Lee[5,6]
[1]Environmental Science Graduate Program, The Ohio State University, Columbus, Ohio; [2]Department of Environmental and Global Health, University of Florida, Gainesville, Florida; [3]Emerging Pathogens Institute, University of Florida, Gainesville, Florida; [4]School of Earth Sciences, The Ohio State University at Mansfield, Mansfield, Ohio; [5]College of Public Health, Division of Environmental Health Sciences, The Ohio State University, Columbus, Ohio; [6]Department of Food Science and Technology, The Ohio State University, Columbus, Ohio

Zebra mussel invasion of northern American lakes during the last century may play an important role in the occurrence of toxic cyanobacteria blooms. Herein, large-scale data from the USEPA National Lake Assessment (> 1,000 lakes) were used to study the potential linkage between zebra mussels, cyanobacteria community composition, and cyanotoxin levels in the lakes. ANOVA Based on Dissimilarities tests (Adonis) showed that there was a significant difference in cyanobacterial communities between lakes located in areas with and without established zebra mussel populations. Meanwhile, significantly higher microcystin levels and cyanobacteria abundance were observed, but lower concentrations of phosphorous in lakes located in areas with established zebra mussels. Structural equation modeling was used to confirm and estimate the effect of zebra mussels on microcystin concentrations via different pathways. The results suggest three potential pathways whereby zebra mussels influence microcystin production: 1) altering phosphorous concentration; 2) increasing cyanobacteria abundance; and 3) shifting cyanobacteria community structure. The total effect of zebra mussel establishment resulted in an overall 1.40 times net increase in microcystin level, which presumably resulted from three contributing factors: 1) a 1.06 times increase through an increased cyanobacteria abundance; 2) a 1.53 times increase through a selective force, resulting in increased cyanobacteria toxicity; and 3) a 0.86 times decrease in microcystin level through total phosphorus decrease. The study suggested the important potential role of zebra mussel invasion in altering cyanobacterial composition and influencing microcystin levels in the US lakes.

Cyanobacterial Combat: The Battle to Manage pH in a Naturally-Acidic Groundwater-Fed Lake

Diane Lauritsen[1] and Linda Ehrlich[2]
[1]Envirochem, Wilmington, North Carolina; [2]Spirogyra Diversified Environmental Services, Burlington, North Carolina

White Lake is a shallow, groundwater-fed natural lake located in North Carolina's Coastal Plain. It is one of a number of distinctive Bay Lakes found in the region, with an elliptical shape and elevated sand rim. While most of the Bay Lakes are acidic, blackwater systems, White Lake has been very acidic (pH levels 4.2–4.4 SU) but clear, and the water clarity and sandy shoreline have made it a very popular recreational lake for generations of North Carolinians. Within the past decade there has been a decline in the clarity of the water and a dramatic change in its acidity; there are now periods in which the water is not acidic, but basic, as a result of elevated productivity

and the very low alkalinity of the water. With the changing of the lake chemistry from acidic to basic, conditions favoring harmful cyanobacteria and the invasive aquatic weed *Hydrilla* were established. A cyanobacterial bloom, dominated by the filamentous *Planktolyngbya limnetica*, developed in late summer 2017 which greatly affected water clarity, and chlorophyll *a* levels exceeded the state standard of 40 mg/L for the first time. The bloom persisted into the spring of 2018, and by early May the mean algal biovolume was 151,577 mm^3/m^3, mean chlorophyll *a* was 52 mg/L, and the Secchi depth was 0.5 m. As a result, pH levels increased substantially (9.1–9.6 SU) throughout the lake. The Town of White Lake received approval to arrange for and fund an in-lake treatment with alum to flocculate and remove algae and nutrients from the water column, and the treatment was completed by mid-May. The alum treatment significantly reduced pH levels, gradually and significantly improved water clarity, eliminated the two filamentous cyanobacteria (*Aphanizomenon* was the second-dominant taxon in early May) and reduced levels of both N and P. Given the long residence time, the apparent increase in both external and internal nutrient loading rates, the productivity-pH feedback loop, and more frequent extreme weather events such as Hurricane Florence, White Lake will likely be at risk for future cyanobacterial blooms that could significantly impact ecosystem health and public use of the lake. The challenge will be to develop consensus and a spirit of collaboration among stakeholders as further management options are assessed.

Session G4: Voice of Experience

3:30 pm – 5:00 pm | West Meeting Room 264

A Day in the Life

Stephen J. Souza
Princeton Hydro, LLC, Ringoes, New Jersey

It is difficult to believe that my career in applied limnology started over 35 years ago! My first NALMS conference was the 3rd Symposium held in Knoxville, Tennessee in 1984. Throughout the years NALMS has always played a significant role in how I went about studying and managing lakes. My career has been exclusively within the private sector. However, that gave me the opportunity along the way to conduct work for a very diverse client base consisting of private, public, NGO and governmental entities.

My career has had a number of milestone moments, but the two that were the most significant were joining the start-up company Coastal Environmental and forming Princeton Hydro. Both involved a substantial amount of risk and uncertainty but were driven by the need to "do the right thing." This "Voice of Experience" presentation deals with the challenges of working as a consultant in the private sector. The presentation deals with how the foundation of commercial success is built upon conducting good science, maintaining a moral compass, and having the ability to adapt your business model to a changing business environment. It also discusses how doing so is key to developing and nurturing long-term relationships with clients.

40+ Years of Rowboat Limnology: What a Ride!

Ken Wagner
Water Resource Services, Wilbraham, Massachusetts

I never intend to truly retire; lake work is too much fun, but I have cut back substantially in 2018. It feels like the long slow-down straightaway at the end of a rollercoaster ride; the exhilaration of the ride is still fresh, and it is not over, but I no longer have the anticipation I had at the start. I am one of those rare people who knew what they wanted to do from an early age and did it. I lived across the street from a lake in New Jersey until I was 13 and was fascinated by everything aquatic from an early age. I studied algae even before I went to college and worked for the NJDEP lakes program for 4 years before expanding my biological horizons at grad school. I went to work in consulting at the start of 1985 and worked for successively larger firms until 2010 when I started WRS, always working on water issues and usually on lakes or reservoirs. It has never been boring. I started out typically naïve and idealistic, thinking I could play with algae and bugs, promote "green" solutions and not really deal much with people. A lot of other professionals made me a much better lake manager over time. I will relate key things I learned along the way, including that lake management is about people more than lakes and that you should never answer a work phone after 2 PM on a Friday!

67 Years of Streams, Lakes, Reservoirs and Oceans: A Wet Life!

Alex Horne
University of California, Berkeley, California

Like Ken Wagner, my ecological interests started early, but in coal, steel, and railways-dominated industrial northern England not Jersey. From 1951-3, I made drawings depicting the changes in location of rooks (colonial crows) nests in large deciduous trees. Only 8 years old, I was innocent of statistics but discovered that rooks were faithful to their locations even though winter winds destroyed the nests. Sadly, I also observed how, but not why, acid coal mine slag heap runoff restricted sticklebacks in local streams. And I remember England's "Silent Spring" though more due to the decline in butterflies I collected than songbirds. A biochemistry major, my graduate career started in 1964 taking samples of blue-green algae (cyanobacteria) in eutrophic Mutton Chop Pond on Hampstead Heath in London. Research on nitrogen and carbon fixation lead me to the English Lake District, Antarctic oceans and wetlands, African lakes, and California. In 1970, consulting and research in the US included lakes, reservoirs, rivers, estuaries, and coastal and tropical oceans in all 7 continents – over 500 projects to date! Recent projects include lake and reservoir restoration with oxygenation, dredging, aeration, and biomanipulation, wetlands construction for targeted pollution removal and oil pollution in the Gulf of Arabia. I have learned a lot, but three concepts are relevant for NALMS members. They are (1) A hidden key (2) A least worse choice and (3) Patience.

Session G5: Watershed and Water Management

3:30 pm – 5:00 pm | South Meeting Rooms 237–238

Some Stormwater Ponds Release Phosphorus

★ **Vinicius Taguchi[1], Tyler Olsen[2], John Gulliver[1], Ben Janke[3], Poornima Natarajan[1], and Jacques Finlay[4]**
[1]St. Anthony Falls Laboratory, Department of Civil, Environmental, and Geo-Engineering, University of Minnesota, Minneapolis, Minnesota; [2]Barr Engineering, Minneapolis, Minnesota; [3]St. Anthony Falls Laboratory, Department of Ecology, Evolution, and Behavior, University of Minnesota, St. Paul, Minnesota; [4]Department of Ecology, Evolution, and Behavior, University of Minnesota, St. Paul, Minnesota

Stormwater retention ponds are ubiquitous in many urban landscapes but are not given much consideration post-construction. High total phosphorus (TP) concentrations from pond grab sample data for 98 ponds in Minnesota suggest that urban stormwater ponds may be releasing phosphorus (P) to receiving water bodies due to high internal loading. This is alarming because retention ponds are one of the most frequently implemented stormwater control measures (SCMs) targeting phosphorus removal. Laboratory incubations of intact sediment and water cores from 5 ponds suggest that mobile-P concentrations (iron-bound P, loosely-bound P, and labile organic P) in pond sediments and sediment oxygen demand (Smax) are indicators of P release potential. Actual P release was measured under anoxic (dissolved oxygen (DO) < 1 mg/L) conditions and was observed to be negligible under oxic conditions (DO > 1 mg/L). However, in-situ field monitoring revealed that several shallow stormwater ponds in the Twin Cities Metro Area are so strongly stratified during the spring and summer months as to prevent diurnal mixing and reoxygenation of the water column from periodic storm events. Conductivity profile measurements suggest that this is likely due to chemostratification from chlorides applied as road salt during the winter months. The resulting anoxic conditions at the sediment-water interface throughout much of the year would facilitate P release into the water column and subsequently downstream receiving water bodies.

Utilizing EPA Green Infrastructure Toolkit to Evaluate Potential Management Strategies for an Urban Watershed

★ **Monica Matt**
State University of New York College at Oneonta Biological Field Station, Cooperstown, New York

The internet provides countless resources for scientists, lake managers, and educators. One such resource includes the Green Infrastructure Modeling Toolkit by the US Environmental Protection Agency (EPA). This collection of 5 downloadable programs and 1 online application can help individuals to better understand green infrastructure, compare environmental outcomes with various stormwater management techniques, and design watershed best management practices (BMPs). Each computer program is unique and requires different levels of technical expertise, geospatial data, and amount of defined physical parameters. Utilization of these innovative programs will aid the development of potential watershed and stormwater management practices for Lake Ronkonkoma, New York. The lake is located in Suffolk County and is the largest lake on Long Island. The watershed is predominantly residential and developed; green infrastructure practices in this area may assist future efforts to reduce runoff volume and external nutrient loading.

Ecosystem Service Assessment of Stormwater Management Features in Greater Cleveland

Julie Wolin and Brittany Dalton
Cleveland State University, Cleveland, Ohio

Greater Cleveland is focused on improving Lake Erie water quality and capturing stormwater runoff in neighborhoods. Stormwater management has been incorporated into green and complete street designs, and repurposed vacant lands. This provides an opportunity to assess the efficacy of green infrastructure in stormwater capture, and the ecosystem services and societal benefits created (*i.e.*, increased biodiversity, pollinator habitat, reduced urban heat island effects, improved neighborhood recreation or aesthetic value). We assessed surrounding land use and maintenance practices in green infrastructure throughout Greater Cleveland. Site visits were conducted for 164 bioretention and rain gardens. Sites were assessed for physical characteristics, surrounding land use, and overall function, including level of erosion and exposed soils. An initial survey recorded all plants present, including invasive species, and each site was revisited for a final plant survey. We analyzed invasive species presence, maintenance practices, and resident awareness and acceptance. The presence of invasive plants can impact the ability of green infrastructure to function properly and provide the ecosystem services as originally intended. Invasive species presence was correlated with increased impervious surface, surrounding land use dominated by human activities, and poor maintenance practices. We also found residents were often unfamiliar with the purpose of rain gardens and bioswales. Improper care and maintenance resulted in the loss of beneficial plants and provided an avenue for invasive species. Resident perception varied widely. Some viewed stormwater management systems as weedy and unkempt, thus affecting the potential for widespread use.

The State of the Lake: Communicating Watershed Science and Engaging Stakeholders in the Lake Champlain Basin

Ellen Kujawa
Lake Champlain Basin Program, Grand Isle, Vermont

Lake Champlain, often termed the "sixth great lake" is an important ecological and economic resource for stakeholders in New York, Vermont, and Quebec. Since the founding of the Lake Champlain Basin Program, the organization has worked to communicate the condition of the Lake to these stakeholders: one tool for this communication is the *State of the Lake and Ecosystem Indicators Report*, released every three years. The 2018 *State of the Lake* focused on four goals for the Lake and Basin: clean water, healthy ecosystems, thriving communities, and an informed and involved public. The report presents the most recent information on the conditions of Lake Champlain and its watershed, including phosphorus loading, cyanobacteria and beach closures, mercury

in fish tissue, invasive species, flooding, and climate change, and highlights the results of some of the management actions undertaken in the Basin. This document serves as a record of the status of the Lake and provides public stakeholders with an opportunity for education and engagement. This presentation will discuss the research, analysis, writing, and design necessary to compiling this document, and the uses it has in the watershed.

Friday, November 2

Session H1: Molecular Techniques for HABs

8:30 am – 10:00 am | West Meeting Rooms 260–261

Evaluation of CyanoDTec Multi-Plex qPCR Assay as a Cyanotoxin Screening Tool for Ohio Public Water Systems and Inland Lakes

Heather A. Raymond[1], Ruth A. Briland[1], and Jorge Santo Domingo[2]
[1]Ohio Environmental Protection Agency, Division of Drinking and Ground Waters, Columbus, Ohio; [2]US Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio

Ohio EPA utilized the CyanoDTec qPCR assay to quantify total cyanobacteria (16S rDNA), and microcystin (mcyE), saxitoxins (sxtA), and cylindrospermopsin (cyrA) genes at 118 public water system source waters and 24 inland lakes. Samples were collected biweekly year-round at PWSs for qPCR and MC-ADDA ELISA analysis. Saxitoxins and cylindrospermopsin were analyzed if sxtA or cyrA were detected. All three cyanotoxins were analyzed and paired with phytoplankton enumeration at inland lakes. mcyE was detected in source waters for 57 PWSs and six inland lakes and microcystins were detected at 45 PWSs and five inland lakes. The number of samples positive for microcystins but negative for mcyE was low (2% for PWS; 15% for inland lakes). At several sites, detection of mcyE preceded microcystins detections by 1–4 weeks. sxtA was detected at 33 PWSs and 14 inland lakes, and saxitoxins were detected at 15 PWSs and 10 inland lakes. Less than 2% of PWS and inland lake samples had saxitoxins detections without corresponding stxA detections. Samples with cyanotoxin detections that lacked corresponding gene detections often occurred following bloom senescence and cyanotoxin concentrations were low. At one PWS, mcyE, sxtA, and cyrA were all detected, demonstrating multi-plex assay functionality. An interlab method comparison was conducted on a subset of samples. qPCR results out-performed cyanobacteria cell counts as a predictor for inland lake cyanotoxin production. 16S rDNA sequencing analyses linked most cyanotoxin positive samples to *Planktothrix* or *Microcytis* species, although in a few samples dominant species were *Aphanizomenon*, *Dolichospermum*, *Cylindrospermopsis*, *Phormidium*, and *Leptolyngbya*.

Using Molecular Analyses to Help Understand and Manage Waters Affected by Cyanobacterial Harmful Algal Blooms

Erin Stelzer[1], Amie Brady[1], Jessica Cicale[1], Joseph Duris[2], Mary Anne Evans[3], Donna Francy[1], Carrie Givens[4], and Keith Loftin[5]
[1]USGS Ohio-Kentucky-Indiana Water Science Center, Columbus, Ohio; [2]USGS Pennsylvania Water Science Center, New Cumberland, Pennsylvania; [3]USGS Great Lakes Water Science Center, Ann Arbor, Michigan; [4]USGS Upper Midwest Water Science Center, Lansing, Michigan; [5]USGS Kansas Water Science Center, Lawrence, Kansas

Toxic cyanobacterial harmful algal blooms (cyanoHABs) are of concern in many parts of the world because of their effects on drinking water, water-based recreation, and watershed ecology. These toxins have been implicated in human and animal illness and death in over 50 countries and in at least 36 states in the United States. Human health risk from cyanoHABs is commonly associated with ingestion or inhalation of toxins. Microscopy has been used traditionally to identify and quantify the different cyanobacterial genera; however, not all strains within a genera have the ability to produce a toxin. Also, in recent years it has become apparent that the microbial community plays a role in determining if and/or which cyanobacterial strains become dominant during a bloom. Molecular methods such as quantitative polymerase chain reaction (qPCR) and next generation sequencing are useful tools for understanding and managing waters affected by cyanoHABs.

This presentation highlights two USGS-led research studies that feature molecular methods. The first study uses monitoring and prediction tools to help make informed decisions on potential occurrence of harmful levels of toxins in recreational and drinking waters. Site specific models are developed using factors significantly related to toxin concentrations, including concentrations of cyanobacterial genes, at Lake Erie and inland lakes in Ohio. The second study is designed to better understand the abiotic and biotic factors that influence cyanoHABs and toxins. This study is focused in the western basin of Lake Erie, but other sites include Saginaw Bay, Lake Huron and Grand Traverse Bay, Lake Michigan.

Structure and Physiological Activity of Cyanobacterial Communities in a Freshwater Lake: A Three-Year Study Using 16S rRNA Gene Sequencing Analysis

Jorge W. Santo Domingo, Aabir Banerji, Mark Bagley, Jody Shoemaker, Daniel R. Tettenhorst
US Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio

While cyanobacteria are common phototrophic inhabitants of natural water systems, they can also pose significant hazard to humans and other biota via toxic by-products known as cyanotoxins. Standard cyanobacterial monitoring relies on time consuming microscopic methods that may not easily discriminate between different groups and that do not provide information on their physiological status. To circumvent these issues, we used next-generation sequencing to generate 16S rRNA gene metabarcoding libraries for water samples collected from five different sites within a multipurpose freshwater reservoir. Samples were collected over three consecutive years from May to September and both DNA and RNA were used to determine the diversity, relative abundance and physiological activity of the cyanobacteria identified. Analysis of nearly 30 million sequences revealed the presence of 16 different genera within the lake. Of the cyanobacteria known to produce cyanotoxins, *Dolichospermum*, *Planktothrix*, *Microcystis*, *Cylindrospermopsis*, *Aphanizomenon*, and *Pseudanabaena* were the most abundant (in that order). Temporal changes were noted in both relative abundance and activity, with *Dolichospermum* showing the highest levels early during the monitoring period. Sizeable increases in the other aforementioned genera followed after mid-June. Parallel increases in microcystin levels and *Microcystis*

abundance were noted, implicating the latter cyanobacterial group as primarily responsible for toxin production. In summary, we showed that metabarcoding is a robust tool for assessing the diversity of cyanobacteria in natural systems. The results provide the foundation for understanding the population dynamics of cyanobacteria in relation to toxic cyanobacterial blooms.

Nitrogen–Phosphorus-Associated Metabolic Activities and Community Structures During the Development of a Cyanobacterial Bloom Revealed by Metatranscriptomics

Jingrang Lu[1], Bo Zhu[2], Ian Struewing[3], Ning Xu2, and Shunshan Duan[2]
[1]US Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio; [2]Institute of Hydrobiology, Jinan University, Guangzhou, Guangdong, China; [3]Pegasus Technical Services, Cincinnati, Ohio

The increasing harmful cyanobacterial blooms (HABs) have potentially had threat to human health and ecosystem stability, and HAB control has been focused on the reduction of nutrients. However, recent studies suggest that nitrogen (N) from cyanobacterial N_2-fixation may contribute to HABs. Our analysis of metatranscriptomic sequences from Harsha lake, Ohio, revealed the expression of upregulated gene clusters associated with nitrogen and phosphorus (P) metabolism prior to and during a cyanobacterial bloom event. Genes involved in N_2-fixation (nifDKH) and P transport and regulation were significantly upregulated during the bloom compared to a pre-bloom reference date. *Nostoc* and *Anabaena* had major roles in N_2-fixation. However, other cyanobacteria like *Cylindrospermopsis*, *Cyanothece*, *Arthrospira Trichodesmium*, etc. were also important. The activities of N_2-fixation were associated with high P and low N or low N/P ratios and high relative abundance of active cyanobacterial N_2-fixers, while those of phosphorus accumulation were associated with low P or high N/P ratios and increasing *Microcystis*. The results indicate that the early summer N_2-fixation activities linked to the decreased N/P ratios, the existing active N_2-fixers, a following HAB, cyanobacterial community successions and cyanotoxin productions.

Session H2: Nutrient Modelling and Monitoring

8:30 am – 10:00 am | West Meeting Room 262

A Water and Mass Balance Model for Evaluating Phosphorus Pathways and Lake Improvement Strategies in Three Shallow, Eutrophic Lakes in the Upper Midwest

Charles Ikenberry[1], Bob Gregalunas[2], Sara Mechtenberg[2], and Mike Sotak[2]
[1]FYRA Engineering, Des Moines, Iowa; [2]FYRA Engineering, Omaha, Nebraska

It is well-established that phosphorus is typically the limiting nutrient for algal growth and a driver of eutrophication in freshwater lakes. Therefore, phosphorus reduction is a common objective of lake management. Many improvement projects utilize a "random acts of conservation" approach while planning efforts utilize simplistic models that predict average, steady-state conditions. This presentation describes a dynamic and comprehensive water and mass-balance modeling approach that quantifies distinct phosphorus pathways and potential impacts of water quality improvement strategies in shallow, eutrophic lakes.

The approach utilized GoldSim, a simulation software for dynamic modeling of complex systems. The software employs Monte Carlo methods to quantify uncertainty, which aids the decision-making process. Key inputs and processes represented include precipitation, streamflow, evaporation, outlet configuration, groundwater/seepage, pumping for irrigation and water supply, phosphorus sedimentation, and sediment-phosphorus release, which was informed by sediment core chemistry.

Annual loading rates from external sources varied between lakes, ranging from 0.7 to 11.7 g-P/cm^2, while internal loads varied from 0.7 to 10.5 g-P/cm^2. Relative importance of internal loading varied with time, but was similar across lakes, with growing season internal loads accounting for 40% to 60% of total load. Phosphorus reduction goals ranged from 40% to 70%. Simulated improvement alternatives included reduction of external phosphorus, diversion of inflows, rough fish management, in-lake wetlands, dredging, and internal load control. Due to unique watershed and lake characteristics, effectiveness of improvement alternatives varied by lake. Stochastic simulation informed the decision-making process by identifying important data gaps and quantifying the probability of goal attainment.

Modeling Phosphorus and Nitrogen Loading Throughout the Entire Great Lakes Basin Using SPARROW

Glenn Benoy[1], Dale Robertson[2], Dave Saad[2], Ivana Vouk[3], and Richard Burcher[3]
[1]International Joint Commission, Ottawa, Ontario, Canada; [2]US Geological Survey, Middleton, Wisconsin; [3]National Research Council, Ottawa, Ontario, Canada

Eutrophication problems in the Great Lakes are caused by excessive nutrient inputs (primarily phosphorus, P, and nitrogen, N) from various sources throughout its basin. In order to develop nutrient protection and restoration plans, it is important to understand where and from what sources the nutrients originate. As part of a binational effort, new SPARROW (SPAtially Referenced Regression On Watershed attributes) watershed models were developed to simulate P and N loading in streams throughout the entire Great Lakes Basin; previous SPARROW models only simulated US contributions. The new models cover the entire Basin at higher resolution (~2 km^2 catchments) enabling improved descriptions of where nutrients originate and what are the dominant sources of P and N at various spatial scales. The new models were developed using harmonized geospatial datasets describing the stream network, nutrient sources (location and quantity), and the environmental characteristics affecting nutrient delivery. The models were calibrated using loads estimated from sites monitored by US and Canadian organizations. Model results are being used to estimate the P and N input to each of the Great Lakes, compare loading

and yields from various tributaries and governances, and estimate the relative importance of each nutrient source, including the upstream lakes.

Long-Term Shallow Lake Nutrient and Water Quality Management in an Agricultural Watershed Using Conservation Management Practices

Richard Lizotte, Martin Locke, Lindsey Yasarer, Ronald Bingner, R. Wade Steinriede
USDA-ARS National Sedimentation Laboratory, Oxford, Mississippi

Because of intensive row-crop agriculture in the Lower Mississippi River Basin, freshwater systems in the basin are characterized by elevated suspended sediment, eutrophication and poor water quality. The study lake, Beasley Lake, is a shallow isolated oxbow lake that suffered from poor water quality prior to expansion or implementation of several conservation management practices. Practices included: edge-of-field vegetated buffers (VB); constructed sediment pond (SP); conservation reserve areas (CRP); and within-field conservation tillage. Over a 20-year period (1998–2017) measured water quality included suspended sediment (SS), Secchi visibility depth (Secchi), soluble orthophosphate (PO_4-P), total phosphorus (TP), nitrate nitrogen (NO_3-N), ammonium nitrogen (NH_4-N), total nitrogen (TN), and chlorophyll *a*. During the 20-year study period water quality showed significant improvement. SS decreased > 72% from 1998–2002 due to implementation of VB in 2001–2002. Concomitant with SS reduction, Secchi increased > 5-fold from 1998–2008. Phosphorus as PO_4-P decreased nearly 90% from 2002-2015 after SP construction while TP decreased > 90% from 1999–2017 due to VB implemented in 2001–2002 and expanded to attract quail *(Colinus virginianus)* in 2006. Nitrogen as NO_3-N decreased > 95% nearly identical with TP. NH_4-N first decreased by > 95% from 1999–2005 due to VB and CRP but then increased 10-fold from 2009–2014 due to SP. In contrast, TN appeared to be unaffected by any conservation practice. Algal biomass, chlorophyll *a*, increased 8-fold from 2005–2012 due to decreasing SS and increasing Secchi after VB implementation. The study provides evidence of decreased SS and nutrients improving water quality as a result of conservation management practices.

Session H3: Utilizing Citizen Science

8:30 am – 10:00 am | West Meeting Room 263

LakeKeepers: Expanding Citizen Based Monitoring in Alberta, Canada

Bradley Peter and Laura Redmond
The Alberta Lake Management Society, Edmonton, Alberta, Canada

Current lake monitoring strategies, such as the Alberta Lake Management Society's LakeWatch program, restrict much of the Alberta's data to lakes easily accessible from major urban centres – however, many of Alberta's invaluable water resources exist outside of this range. As a result of the remote nature of many of these lakes, water quality data and monitoring history is minimal. The LakeKeepers pilot project aims to address the gaps in lake water quality data that exist in many parts of Alberta. LakeKeepers was piloted at five lakes in Alberta during the summer of 2018, allowing citizen scientists to collect information on temperature, nutrients, chlorophyll *a*, clarity, and invasive species. This presentation will: include an overview of the Alberta Lake Management Society, include a discussion of the LakeKeepers program design, including training materials and videos, present the results from the first year of monitoring, and explore the successes and challenges faced in the delivery of the program.

Combining Citizen Science with Remote Sensing to Monitor Lake Storage

Grant Parkins[1], Tamlin Pavelsky[2], Sarah Yelton[1], and Megan Rodgers[1]
[1]Institute for the Environment, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina; [2]Department of Geological Sciences, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina

Of the 20–40 million lakes in the world larger than 0.01 km^2, only a few thousand receive regular water level monitoring. On-the-ground, automated monitoring of a fraction of these lakes would incur considerable expense. However, an inexpensive staff gauge installed in a lake can be read by anyone, making this an attractive alternative if a system is in place to collect and report the data.

The Lake Level Monitoring Project (LLMP) engages citizen scientists in monitoring lake levels at regular intervals. This data is combined with lake surface area measurements, calculated using satellite imagery from Landsat8 and Sentinel 2 satellites, in an effort to understand how the quantity of water stored in lakes changes over time.

In the first year of the project, LLMP has collected more than 700 lake level and 300 lake area measurements from 11 lakes in eastern North Carolina. We have found that lake level measurements submitted by citizen scientists are highly accurate when compared to pressure transducers installed at the same sites. We have found that lake stage variations are correlated within local clusters of lakes but have found that correlations among distant lakes are not significant.

During this session, we also share strategies for developing a citizen science project, consider the motivations of citizens who participate in LLMP, and discuss feedback they have provided regarding our data reporting systems. Finally, we share plans for expanding our lake network to 200 additional lakes in the United States, Europe, and Asia within 3 years.

In Search of the Complete Picture: Indiana Lakes Trophic Classification Comparison Across Citizen Science, State, and National Monitoring Programs

★ **Heather Bearnes-Loza and Sarah Powers**
Indiana Clean Lakes Volunteer Lake Monitoring Program, Bloomington, Indiana

Lake monitoring programs across the country are designed to meet specific needs. The Indiana Clean Lakes Program was developed in 1989 in partnership with the Indiana Department of Environmental Management's (IDEM's) Office of Water Quality to facilitate a multifaceted approach for assessing Indiana's lakes. The primary monitoring goals of this program are to assess Indiana's lakes utilizing snapshots of water quality through random annual

samplings, and on a long-term scale using volunteer citizen scientists to collect data at the same lakes over time. The National Lakes Assessment (NLA) and its state intensification program is an additional monitoring tool used in Indiana to help understand our lakes and the relationships to other lakes across the nation.

Each of these monitoring methods is unique. Direct comparison of the trophic classification of Indiana's lakes in 2007, 2012, and 2017 reveals distinct differences in the distribution of lake trophic classes in Indiana through each of these monitoring programs. In this talk, we will look at these differences, explore the likely causes, and demonstrate the need and value of each program as a distinct monitoring tool.

Lake Observer: A Mobile App for Recording Lake and Water Quality Observations Across the Globe

Kathleen C. Weathers[1], Holly A. Ewing[2], Kenneth Chiu[3], Lisa Borre[1], and Michael Forcella[4]
[1]Cary Institute of Ecosystem Studies, Millbrook, New York; [2]Bates College, Lewiston, Maine; [3]Binghamton University, Binghamton, New York; [4]State University of New York New Paltz, New Paltz, New York

Mobile apps are rapidly gaining ground as effective tools for collection and display of scientific and environmental monitoring data. The Lake Observer app project began in 2010 as a partnership among computer, ecosystem, and citizen scientists working with the Global Lake Ecological Observatory Network (GLEON) and Lake Sunapee Protective Association (LSPA). Project partners were interested in developing a tool that allows for easy submission of geo-referenced lake data by research scientists and citizen scientists using a smartphone or tablet. Now available in Android, iOS and web-based formats, the app allows users to record and submit data on water quality, Secchi depth, ice cover, cyanobacteria, and aquatic vegetation while working in the field. Since 2015, Lake Observer has been in use for the Secchi Dip-In, and through a partnership with NALMS and USEPA, collected data are publicly available via the Water Quality Portal. In 2018, the app will be used by an interdisciplinary team of researchers from the Cary Institute of Ecosystem Studies, Dartmouth, and the University of New Hampshire who are developing high-tech tools to monitor cyanobacteria in lakes, predict impending blooms, and identify factors that are degrading water quality. The team will bring together multiple data types collected via satellite, drone, and mobile app. Remotely-sensed data from four lakes in the Northeast will be verified with in-lake sampling data, including those collected by citizen scientists using Lake Observer. Preliminary results, from the perspective of app data collection, will be shared along with a demonstration of the app's latest features.

Session H4: Lake Management Topics

8:30 am – 10:00 am | West Meeting Room 264

Damaging Solar UV Radiation as an Environmental Regulator of the *In situ* Abundance of Mosquito Larvae: A Test of the Relative Importance of Shading from Damaging Solar UV Radiation by DOM and Organismal Capabilities for DNA Repair

Nicole Berry, Craig Williamson, and Erin Overholt
Miami University, Oxford, Ohio

Dissolved organic matter (DOM) is decreasing the transparency of inland waters to ultraviolet radiation (UV), and in turn reducing the potential for sunlight to disinfect surface waters of parasites and pathogens. Northeastern North America (NENA) has experienced over a doubling of DOM concentrations in the last decade, suggesting substantial reductions in solar disinfection potential in this region. Here we extend previous work on the solar disinfection of parasites and pathogens to examine the effects of DOM and reduced exposure to solar UV radiation on disease vectors. Mosquitoes are vectors of disease that are most abundant in shaded habitats and are expanding their habitat range northward into NENA due to increases in both precipitation and average air temperature. Here we ask whether increases in DOM and reductions in solar UV disinfection facilitate the expansion of mosquitoes. We tested the potential for solar UV radiation to be an environmental regulator of mosquito larvae and compared two potential mechanisms for mitigating damage caused by exposure to solar UV radiation: 1) DOM as an environmental mediator to reduce exposure to UV, and 2) photoenzymatic repair as an organismal response to repair DNA damage caused by solar UV radiation. DOM significantly accelerated time to emergence. Exposure to solar UV radiation significantly increased time to emergence. These findings highlight the potential value of solar UV radiation as a natural control of vectors of disease and the importance of considering changes in water transparency in predicting mosquito breeding success and range expansion into NENA.

An Emerging Technology Using a Resilient Fabric Material for Living Shorelines

Bruce Richards and Brian Fischer
Sox Erosion Solutions, Boca Raton, Florida

Shoreline erosion contributes to excessive losses of soil and sediment, reducing habitat in freshwater ecosystems; a new *living shoreline* fabric approach may be the answer. Established practices of vegetative buffering and habitat restoration are of increasing importance to policy-makers, water managers, engineers, and municipal officials. There is overwhelming scientific consensus that each coastal state will experience increased erosion due to the inevitable future rise of sea level attributable to climate change; non-coastal states will follow. A relatively recent holistic approach to stabilizing shorelines is gaining international momentum utilizing a proprietary patented bioengineered material distributed by Sox Erosion Solutions of Boca Raton, Florida. This rigorous fiber technology has been in place for 18 years and has

sustained shorelines with jagged rocky shores along high wave energy embankments. Native plants have been integrated into the fabric shorelines to improve buffering of nutrients particularly phosphorus which adheres to fine grain surface sediments. This presentation will show before and after data of successful installations in a relatively short temporal scale. We will examine data collected from field studies on native plant recruitment, and shoreline habitat improvement. The conclusion will highlight key lessons learned specifically for lake managers. Our presentation will also review our future research project goals as possible opportunities for students or engineering firm collaborations.

Are Carbon Emissions from Lakes on the Rise? Investigating Organic Carbon Degradation by Microbes and Sunlight in Inland Waters

Sarah G. Nalven, Collin P. Ward, Rose M. Cory, George W. Kling, and Byron C. Crump
Wenck Associates, Golden Valley, Minnesota

Inland waters such as lakes and streams are carbon cycling hotspots, emitting as much carbon dioxide (CO_2) to the atmosphere as the net amount removed from the atmosphere by land and ocean plants each year (~2 Pg C y^{-1}). Much of the CO_2 emitted from inland waters is due to microbial respiration of terrestrially-derived dissolved organic matter (DOM) that is flushed from soils to streams and lakes. Sunlight also affects CO_2 emissions from inland waters by directly mineralizing DOM to CO_2, and by modifying DOM to new compounds that microbes may consume slower or faster than DOM that has not been photo-altered. Thus, DOM is a critical intermediate between soil organic carbon and inorganic CO_2 in the atmosphere. Understanding the controls on DOM conversion to CO_2 in inland waters is needed to constrain local and global carbon budgets and to forecast CO_2 emission from inland waters under future climate conditions. We conducted an experiment in which DOM leached from the organic layer of tundra soil was exposed to natural sunlight (light treatment) or kept in the dark (dark control), incubated with a soil microbial community, and analyzed for gene expression and DOM composition. This experimental manipulation and the resulting microbial gene expression showed that sunlight exposure of terrestrially-derived DOM initially stimulated microbial growth by 1) replacing the function of enzymes that degrade higher molecular weight DOM such as enzymes involved in aromatic degradation, oxygenation and decarboxylation and 2) releasing nutrients such as phosphorus and iron. However, photo-production of growth-stimulating compounds came at a cost. Sunlight depleted the pool of aromatic organic compounds that supported microbial growth in the dark control, ultimately causing slower growth in the light treatment over 5 days. These first measurements of microbial gene expression in response to photo-alteration of DOM provide a mechanistic explanation for how sunlight exposure of terrestrial DOM causes rapid changes to microbial degradation of organic carbon.

Winter Road Maintenance: Identifying and Lowering Private Companies' Barriers to Adopting Best Management Practices

★ **Holden Sparacino and Kristine Stepenuck**
University of Vermont, Burlington, Vermont

Winter road maintenance keeps roads free of snow and ice, but can also negatively impact surface water quality, pose risks to aquatic life, and may contaminate groundwater and increase risks of contamination for private wells or public drinking supplies sourced from groundwater. Many municipalities have adopted preventative measures (best management practices) to reduce salt use as environmental impacts have grown and materials costs have risen to minimize environmental impacts and save money while providing a similar level of service.

However, it is largely unknown if private contractors who maintain private roadways, driveways, commercial parking lots, and sidewalks have adopted these practices, and what their motivations and barriers to adopting best management practices are. In this talk, an ongoing mixed-methods study in the Lake Champlain Basin and preliminary results will be discussed. The study seeks to identify the current practices of private contractors through quantitative survey data, using these findings to inform qualitative interviews to further explore the barriers and motivations of private contractors to adopt best management practices. Mixed-methods data will be used to create recommendations for community-based social marketing outreach and learning opportunities for contractors. Ultimately the study and recommendations aim to increase private contractors' awareness of environmental and economic outcomes of their practices and lower barriers to adopting new, lower salt best management practices.

Session I1: Molecular Techniques for HABs

10:30 am – 12:00 pm | West Meeting Room 262

Evidence-Based Guidelines for Microbial Source Tracking Projects

James Herrin, Mauricio Larenas, Daron Stein, and Yiping Cao
Source Molecular Corporation, Miami, Florida

Lake and reservoir managers face diverse challenges maintaining water quality to support multiple uses. Fecal bacteria are a leading cause of impairment in these systems in the United States. Methods used to monitor indicator bacteria do not provide information about the source of the pollution and remediation is difficult, particularly in watersheds with nonpoint sources. Advances in microbial source tracking (MST) technologies are revealing the source of fecal bacteria.

Focusing on lessons learned and outcomes achieved from two MST projects, we will present evidence-based guidance on crafting effective MST programs.

1) The City of Boise closed multiple beaches after measuring high levels of *E. coli*. Water samples were analyzed for dog, goose and human bacteria. Results indicated consistent pollution from dogs. Human and goose fecal biomarkers

were detected less frequently. Parks officials imposed stricter regulations on dogs at these sites, *E. coli* concentrations decreased, and the beaches were reopened.

2) Sunshine Lake and Sunrise Waterway system in Charlotte County, Florida experienced persistent algal blooms. Officials initiated a monitoring program that included fecal bacteria to develop a management plan. Water samples were analyzed for bird, dog and human fecal bacteria. The frequencies of detection were less than 1%. An experiment revealed that decomposing grass clippings created a greater spike on fecal coliform plates than either soil or dog waste collected around the lake.

Adaptation of Lake Erie *Planktothrix* Blooms to Shifts in N Availability

★ **Michelle Neudeck, Robert M. McKay, and George Bullerjahn**
Bowling Green State University, Bowling Green, Ohio

Sandusky Bay (Lake Erie) harbors a toxic persistent cyanobacterial HAB from May through October in which microcystin levels can routinely exceed 20 ppb. The waters are shallow, turbid, and eutrophic, providing ideal conditions for *Planktothrix*, the dominant cyanobacterium. N levels are high while Sandusky River discharge is high, but due to denitrification DIN rapidly decreases to below detection when river discharge is low. *Planktothrix* persist under the conditions of low N, despite being non-diazotrophic. Metatranscriptomic data demonstrates *Planktothrix* actively stores N under replete conditions by producing cyanophycin, a N storage polymer. It is able to retrieve N from cyanophycin during depleted conditions through production of the enzyme cyanophycinase. Under prolonged N deprivation, *Planktothrix* produces the transcripts for *nblA*, which encodes a protein that can trigger the degradation of the phycobilisome to be used as an additional N source. Even though the bay is turbid, *Planktothrix* is under light stress as indicated by the transcription of a high light stress inducible protein, *hliA*. These physiological features present management challenges distinct from those employed to mitigate Lake Erie *Microcystis* blooms.

Session I2: Nutrient Modelling and Monitoring

10:30 am – 12:00 pm | West Meeting Room 263

The Heidelberg Tributary Loading Program: Perspectives from Between the Land and Lake

Laura Johnson, David Baker, Remegio Confesor, and Ellen Ewing
Heidelberg University, Tiffin, Ohio

The National Center for Water Quality Research has been monitoring major tributaries to Lake Erie for over 40 years as a part of its Heidelberg Tributary Loading Program (HTLP). A minimum of one sample and, during storm runoff, up to three samples a day are analyzed for all major nutrients and suspended sediments from five major tributaries to Lake Erie (Maumee, Sandusky Portage, Raisin and Cuyahoga). Long-term trends in loads and concentrations indicate that total phosphorus (TP) has decreased since the mid-1970s in the agricultural watersheds, whereas dissolved reactive P (DRP) has been increasing drastically since the mid-1990s corresponding to the recurrence of harmful algal blooms (HABs) in Lake Erie. Increased DRP and HABs appear to be associated with increased discharge in the past decade as well as recent patterns in agriculture, specifically the build-up of P at the soil surface combined with preferential flow of water to tile drainage. This high frequency water quality monitoring has allowed us to detect dominant sources and dynamics of nutrient runoff from watersheds throughout Ohio and in Michigan. The HTLP has been immensely useful in detecting causes for reeutrophication of Lake Erie, setting new Lake Erie phosphorus target loads, and determining seasonal forecasts for western Lake Erie HABs. By continuing to monitor tributaries to Lake Erie, inland lakes, and the Ohio River, we should be able to adaptively manage our watersheds to ensure future conservation efforts and those already underway are successful.

Assessment of Lake of the Woods' Internal Phosphorus Loading

Julie Blackburn[1], Geoff Kramer[1], Jesse Anderson[2], and Cary Hernadez[2]
[1]RESPEC, Roseville, Minnesota; [2]Minnesota Pollution Control Agency, Duluth, Minnesota

Lake of the Woods (LOW) is an international water that covers 1,485 mi^2 (3,846 km^2) and experiences elevated phosphorus concentrations that peak with progression of the growing season generating algal blooms that may extend into the autumn. LOW is impaired by excess nutrients and a MPCA sponsored Total Maximum Daily Load (TMDL) study for the lake's Minnesota portion was initiated in 2015. This massive lake has been the subject of intense study by MPCA, Canadian provinces of Ontario and Manitoba, Canada Ministry of Environment and Climate Change, the Science Museum of Minnesota (SMM) and the International Joint Commission (IJC). The studies and projects completed include lake water quality samples, automated lake temperature/dissolved oxygen profiles (SMM), updated satellite land cover (UM), HSPF and BATHTUB modeling (RESPEC) and intensive lake sediment P studies (UW Stout). These studies have generated data necessary to develop estimates of internal loading, an important driver of LOW water quality issues but difficult to measure due to the size and complexity of this lake. Converging estimates of internal P loading (about 300 m tonnes per year) were defined by three independent studies with different methodologies: 1) temperature dependent lake sediment P release (UW Stout); 2) historical examination of lake mass balances (SMM); and 3) HSPF monthly P mass balances from the entire watershed with corresponding lake P masses (RESPEC). The results of these studies are being incorporated into discussions for future management decisions by Canadian and US partners responsible for management of Lake of the Woods.

Spatiotemporal Assessment of Water Chemistry Dynamics in the Coastal Dune Lakes

Alexander C. Hyman[1,2] and Dana Stephens[1]
[1]Mattie M. Kelly Environmental Institute, Northwest Florida State College, Niceville, Florida; [2]Choctawhatchee Basin Alliance, Santa Rosa Beach, Florida

Coastal dune lakes of Northwest Florida experience fresh and brackish conditions corresponding to exchange of waters with the sea through breaching of a berm. Decadal-scale trends and multivariate analyses of monthly water chemistry data (*i.e.*, dissolved organic carbon, chlorophyll, pH, total phosphorus, total nitrogen, and water clarity) from 18 coastal dune lakes suggested form and function of these aquatic systems influenced interaction among water chemistry variables. Temporal shifts in water chemistry variables indicated trends towards more biologically productive system in 40% of waterbodies monitored. Principal component analysis showed inter-annual water chemistry relationships ordinated by salinity differences among waterbodies. Simple linear regression indicated significant correlations between salinity concentration and total nitrogen, dissolved oxygen, pH, and water clarity. Factor analysis identified two significant factors (marine connectivity and catchment inputs) which were responsible for major variations in inter-annual water chemistry. Identified water chemistry relationships facilitate development of appropriate management plans and aquatic impairment criteria for these unique waterbodies.

Session I3: Public Outreach

10:30 am – 12:00 pm | West Meeting Room 264

Citizen Science from the Ground Up: UpStream – Building a Public-Private Partnership Between Industry and Public Schools

Ann St. Amand
PhycoTech, Inc, St. Joseph, Michigan

UpStream is a middle school watershed project that incorporates hands-on science learning opportunities inside, as well as in an outdoor classroom. The program is a cooperative effort between a local environmental consulting firm (PhycoTech, Inc.) and the St. Joseph Public School System. After a two-year search for a teaching partner, UpStream was established in 2005 with one teacher and 28 students. It now includes 11 classes, with over 250 students in the 6th grade and 240 students in the 8th grade for Salmon in the Classroom per year. There has been significant administrative and teacher turnover since 2005, along with a change in state educational goals, guidelines and curricula, yet despite the challenges, the base program is thriving, serving over 2500 students to date. One major advantage of this outreach program is that we are able to interact with all students in the target grades, not only those who already excel in science. Hands-on science has particular efficacy with struggling students and students at risk, connecting them with natural resources in a profound way.

Social Marketing Maneuvers, Magic, and Measurable Change!

Jill Hoffmann[1] and Lyn Crighton[2]
[1]White River Alliance, Indianapolis, Indiana; [2]The Watershed Foundation, North Webster, Indiana

Ever wonder how to create a grassroots public education and engagement program that brings about real, measurable environmental change? How about creating a program where others pay you for the right to promote and widely share your messages about water quality? Join us and become a social marketing magician!

Clear Choices, Clean Water is a social marketing campaign focused on how the choices we make impact our lakes and streams. The program's unique strategy to increase awareness and knowledge about topics like lawn care, pet waste, native plants, and septic systems has garnered the attention and financial support of dozens of agencies, nonprofits, utilities, and municipalities. The original vision for the campaign was to change people's behavior about a handful of common water quality issues while simultaneously evaluating the success of such efforts; however, the vision has grown to also include behavior change choices related to water conservation, soil health, tree stewardship, and volunteer participation… and now, *Clear Choices* has grown in its geographical reach with partner organizations implementing the program in New York, Pennsylvania, Ohio, and Missouri!

We will explore how the pledge map, associated pollution reduction estimates, and various website analytics provide both immediate gratification for the pledgee and real-time evaluation for the program administrators. The objectives for the session are to teach participants how to think through what behavior changes they want; customize a program to fit their audiences; build widespread, lucrative partnerships; and implement a cutting-edge, action-focused public engagement program that transcends nearly every watershed stakeholder group.

Session J1: Phytoplankton Ecology

1:30 pm – 3:00 pm | West Meeting Room 262

Annual Patterns of Phytoplankton in Subtropical, Florida Lakes

Dana B. Stephens[1] and Daniel Canfield, Jr.[2]
[1]Mattie M. Kelly Environmental Institute, Northwest Florida State College, Niceville, Florida; [2]School of Forest Resources and Conservation, University of Florida, Gainesville, Florida

Inter- and intra-annual patterns were examined using 20 to 24 years of monthly chlorophyll concentrations estimates from 27 subtropical, Florida lakes. Dominate periods of variance, reoccurrence of the periods, and strength of the variance (peaks) were extracted using spectral density analysis to address timing and frequency (periodicity) of phytoplankton as well as shifts in periodicity across a continuum of biological productivity. Phytoplankton increased from January to September and linearly decreased through December. Periodicity of phytoplankton was similar in pattern among oligotrophic, mesotrophic, and

eutrophic classified waters where phytoplankton reached higher levels during months June through October and lower levels during months November through May. Periodicity of phytoplankton in hypereutrophic waters exhibited bimodal phytoplankton increases in April and October. Variance of periodicity over 20- to 24-year time series showed strength of seasonal phytoplankton patterns were partitioned into quarterly, annual, and centennial time periods. Seasonal variance in mesotrophic and eutrophic lakes occurred on an annual cycle. Phytoplankton peaks in oligotrophic lakes also occurred on an annual cycle, yet weaker seasonal signals were present at quarterly intervals indicating some years exhibited two phytoplankton peaks. Hypereutrophic lakes showed strong annual and quarterly peaks capturing the bimodal phytoplankton pattern throughout out the year.

Internal Loading of Nitrogen and Phosphorus Supports Non-N-Fixing Cyanobacteria in Honeoye Lake

★ Justin Myers[1], Silvia Newell[1], Roxanne Razavi[2], Lisa Cleckner[3], and Mark McCarthy[1]

[1]Wright State University, Dayton, Ohio; [2]State University of New York, College of Environmental Science and Forestry, Syracuse, New York; [3]Finger Lakes Institute at Hobart and William Smith Colleges, Geneva, New York

Honeoye Lake is a small (7.2 km^2), shallow (Z_{max} = 9 m) lake within the Finger Lakes (New York, USA) characterized by an increasing frequency of harmful cyanobacterial blooms. Nitrogen (N) and phosphorus (P) sourced from external (*e.g.*, storm water runoff) and internal loading (*e.g.*, remineralization, N fixation) often control algal growth in lakes. Microbial processes can contribute to nutrient removal (*e.g.*, denitrification) or internal loading. To investigate sediment nutrient dynamics in Honeoye Lake, intact sediment cores were collected in August 2016, June 2017, and September 2017 near the primary tributary inflow and near the middle of the lake. Sediment cores were incubated for three days using bottom water with no amendments (control) or ^{15}N stable isotope additions and sampled daily for nutrients (phosphate, ammonium, nitrate, nitrite, and urea) and dissolved gases (O_2 and N_2). Sediments were a net source of ammonium (mean 222 ± 106 μmol N m^{-2} h^{-1}) and ortho-phosphate (mean 1.5 ± 0.2 μmol P m^{-2} h^{-1}). Reduced N forms dominated the N pool, and nitrate availability limited N removal via denitrification. Internal N and P loading from sediments is periodically mixed to the surface layer by meteorological events, promoting algal blooms and a community shift from N-fixing (*e.g.*, *Gleotrichia*) to non-N-fixing (*e.g.*, *Microcystis*) cyanobacterial taxa. Internal recycling of nutrients, sourced from external loads, contributes to sustaining these blooms during low discharge periods. The challenge for lake managers is to effectively reduce nutrient loads of both N and P to reduce occurrences and toxicity of these blooms.

Session J2: HAB Control

1:30 pm – 3:00 pm | West Meeting Room 263

Reducing Harmful Algal Blooms on a 150-Acre, Hyper-Eutrophic Lake Using a New Biological Treatment Method

John Tucci

Lake Savers LLC, Richland, Michigan

Lake Heritage is a 150-acre, hyper-eutrophic man-made lake located in Gettysburg, Pennsylvania. The lake is situated in a heavily agricultural watershed. Excessive phosphorus inputs and lack of aquatic vegetation leave the lake susceptible to harmful blue-green algal blooms. Bloom conditions persisted despite frequent treatments with copper sulfate. In addition, this 40-foot-deep lake went anoxic below the 10-foot depth from June through fall turnover.

In 2015, Lake Savers was selected to introduce whole lake aeration, biological treatment and inlet nutrient filtration to restore dissolved oxygen levels and break the cycle of chronic algae blooms. In fall of 2015, whole lake aeration was installed, inlet filtration measures were implemented on the three primary inlet points to the lake.

Improvements in dissolved oxygen levels and reductions in percent organic content of sediments were realized. However, there was no discernable improvement in reduction of harmful algal blooms. The lake remained under advisory for microcystin toxins and harmful algal blooms from early July through October of 2016.

While the community realized turning around the lake was a long-term project, there was no possibility of enduring another summer of a virtually unusable lake in 2017. After extensive research into options and alternatives we partnered with an innovative micro-biology company to develop and implement a completely new approach to Biological Treatment for nutrient reduction in lakes. The approach uses a unique, *ex situ* "brewing" strategy to dramatically increase the amount of activated, beneficial microbes that can be applied as compared to off-the-shelf formulations.

From May through October, 2 to 4 treatments were applied per month. The program delivered a 90% reduction in blue-green algae with microcystin levels reduced to near non-detect. Total Phosphorus and Dissolved Reactive Phosphorus levels were reduced more than 50% from 2016. Based on these results, we believe that this new approach to biological treatment offers a promising, economically viable alternative to chemical algaecides for the prevention of harmful algal blooms. Further testing on multiple lakes is planned for 2018 and beyond.

Strategic Management of Cyanobacteria in Drinking Water Reservoirs Using an Action Threshold Based Approach

West M. Bishop
SePRO Corporation, Whitakers, North Carolina

Algae can cause significant impacts to drinking water quality through production of taste and odor compounds, toxins, and disinfection by-product precursors. Due to the difficulty/expense in removing these compounds in the drinking water process, our approach strategically targeted the source (*i.e.*, algae in raw water) and sought to manage at low densities before these compounds could achieve levels of concern. Operational research will be presented on multiple water supply reservoirs throughout the country with a history of algal influenced taste and odor (geosmin, MIB, etc.) issues negatively impacting the quality of the water supply. Routine monitoring assisted in developing action thresholds for the culprit of taste and odor production and levels were set in accordance to preserve management objectives. If an action threshold was exceeded, the appropriate NSF and/or EPA approved product and concentration was strategically applied to the reservoir to control and prevent the expansion of the targeted nuisance algae. Water sample analysis from all reservoirs consistently documented a 78–97% reduction in nuisance algal densities immediately following the application of SeClear® Algaecide and Water Quality Enhancer or PAK® 27 Algaecide, as well as a decrease in geosmin levels and long-term suppression of nuisance algae. Phoslock was also able to mitigate phosphorus in localized areas and improve water quality. This proactive approach to drinking water management can provide significant and rapid relief of nuisance algae, improve source water quality, and decrease in-plant management inputs required to achieve drinking water objectives.

From Bench Scale Trials to Effective Full Scale Cyanobacterial Management with Liquid Activated Peroxygen Algaecide/Cyanobactericide

Tom Warmuth[1], John Rodgers[2], Brian Sak[3], and Tom McNabb[4]
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Development of effective treatments for cyanobacterial management are emerging as a needed option as the threat to our water resources by these organisms becomes more realized and understood. The need for tools to cyanobacteria known to produce harmful toxins and taste and odor compounds is an important ongoing focus in the field of surface water management. Bench Scale trials at Clemson University on bloom level densities of cyanobacteria (1.9 million cells/ml) lead to effective field application rates in full-scale surface treatments of a municipal potable water source. The San Antonio Reservoir is a potable water source for the City of San Francisco. It was experiencing high, 100 ppt, levels of Geosmin production from a cyanobacteria dominating the algal assemblage. The San Francisco Public Utilities Commision, through their program of monitoring, sampling and algal enumeration delivered effective control of *Dolichospermum spiroides* (formerly an Anabaena species) using the lowest labelled rate of a Liquid Activated Peroxygen Algaecide, a NSF/ANSI 60 Certified, liquid activated peroxygen algaecide. Other previous research with peroxide-based algaecides have been identified as effective in selective treatments for cyanobacteria, where it is not greatly affecting non-target organisms, zooplankton, beneficial green algae and other phytoplankton. This all leading to a better potable water source through more targeted treatment and control.

Patterns in Surface Water Phosphorus Concentrations and Biosolids Utilization in the Upper St. Johns River

John Hendrickson, Vickie Hoge, Lanie Meridth, and Erich Marzolf
Division of Water and Lands Resources, St. Johns River Water Management District, Palatka, Florida

The headwaters of the upper St. Johns River (USJR) is an integrated aquatic ecosystem of restored herbaceous marsh and run-of-the-river lakes. The SJRWMD owns and manages over 166,000 acres, a significant portion of the area within the 100-year floodplain, striving to optimize essential flood protection while also restoring normal ecosystem function by minimizing the adverse effects of over-drainage. Despite restoration progress, many of the headwater lakes and streams exhibit significant increasing trends in phosphorus and increasing incidences of harmful cyanobacterial blooms, an ominous manifestation in potable water supply. This upward trend is coincident with an increase in the application of wastewater biosolids on cattle pastures in the basins' western watersheds, and water quality sampling data indicate significant correlations between the cumulative biosolid phosphorus applied within watersheds and runoff phosphorus concentrations. The intensification in application is encouraged in part by a prohibition in the adjacent Okeechobee watershed, elevating the USJR as the next most cost-effective destination for class B biosolids generated in central and south Florida. Current regulations base class B biosolids application rates on crop nitrogen requirements. Phosphorus limits are recommended based on Mehlich-3 extractable P from intermittent soil test result results, a less definitive threshold which, in an environment of biosolids oversupply, could encourage overfertilization with phosphorus and ultimately increased export to surface waters. Additional research is underway to further evaluate the hypothesis linking biosolids application and water quality and to better describe plant available phosphorus from various soil types and biosolids sources, and the modes of phosphorus migration to surface waters.

Session J3: Aeration and Artificial Mixing

1:30 pm – 3:00 pm | West Meeting Room 264

The Future of Bubbles: Novel Applications to Linear Oxygen Diffusing Systems

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Linear air diffusion tubing is a technology traditionally used to aerate ponds and lakes, but it has been adapted to create many new applications generally called bubble curtains. Bubble curtains have been used for HAB, and sediment barriers as well as fish deterrence and garbage collection. One key application is sound attenuation. As awareness of the dangers of underwater shockwaves on wildlife increases, we have shown that there are concrete measures that can be taken to reduce sound stress on wildlife.

There are two main phenomena that lead to sound attenuation by fine bubbles. The first is acoustic, which is the energy loss caused by bubbles increasing the compressibility of the water. The other is thermal, in which the compression of the bubbles generates heat in the bubbles by compressing the air which dissipates energy in the form of temperature transfer to the water. Considering that a reduction of 3 dB is equivalent to halving the available energy, the results of our study showed that sound reduction varied from 9 dB with a single bubble line at low frequencies (100 Hz) to 82 dB with a double line at high frequencies (20 000 Hz).

These results show that linear air diffusion tubing can provide high attenuation of underwater sound, depending on the frequency of the source. While attenuation is more pronounced at high frequencies, it is still sufficiently high at low frequencies to lower the impact of human activities on marine animals and ultimately promote marine health and well-being.

Oxygenation System for Alabama Power's Logan Martin Hydroelectric Plant

Mark H. Mobley[1], James F. Crew[2], Paul Gantzer[3], Kenneth R. Odom[4], R. Jim Ruane[5], and Paul J. Wolff[6]
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Logan Martin Dam is located on the Coosa River near Vincent, Alabama. The reservoir area when full is 15,000 acres. The hydroelectric plant has three generating units with a total generating capacity of 128 MW. Each turbine releases 10,000 cubic feet per second. That is 16,000 MGD with all three turbines operating. Alabama Power and Southern Company are working to obtain a new FERC license for the Coosa River Projects. As a part of the relicensing requirements, dissolved oxygen improvements are being made at Weiss, Henry and Logan Martin hydroelectric plants. All three plants have forced air blower systems and Logan Martin has forebay oxygen diffuser system in addition. The oxygen diffuser system can provide enough oxygen to increase the release of two generators by three milligrams per liter of dissolved oxygen. Seven diffusers are located in the forebay extending about a mile upstream of the dam, utilizing the 65-foot water depth to achieve better than 85% oxygen transfer efficiency. This presentation will include a description of the design and construction of the oxygenation system as well as water quality results as available in the reservoir and releases for the first year of operation.

Not so Fast: Reassessing a Common Rule of Thumb for Destratification System Design

Kevin Bierlein, Christine Hawley, and Jean Marie Boyer
Hydros Consulting Inc., Boulder, Colorado

Destratification systems have been used as an in-lake management tool for many decades. They have been applied to limit anoxia and associated water-quality issues, to reduce algae and cyanobacteria growth, and maintain a uniform source water for drinking water treatment.

Diffused air systems are one of the most common types of destratification systems. Although each installation and design is unique, the oft-cited rule of thumb in designing a diffused air destratification system is 1.3 SCFM/acre (9.2 m^3/min/km^2). This number was originally presented by Lorenzen and Fast (1977) and is often used as a key design parameter. Yet many case studies indicate that management goals may not be achieved even when the system design is based on this rule of thumb.

Since destratification systems often have high capital and operating costs, it is imperative that a system is appropriately designed to avoid wasting limited resources. How can we improve the destratification system design process and increase the likelihood of achieving the desired management goal? Why haven't design methods progressed beyond this 40-year old rule of thumb? This presentation provides a critical review of how the Lorenzen and Fast rule of thumb was developed, how it has been misapplied over the years, and presents a path forward to improve destratification system design.

Quantifying Mixing Effectiveness for Water Quality Improvements in Lakes

Paul Wolff[1], Andy Sawyer[2], G. Chris Holdren[3], and Jim Ruane[2]
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Artificial mixing is an effective in-lake restoration method that can improve water quality by reducing internal nutrient loading and by reducing the severity of cyanobacteria blooms. Mixing can increase hypolimnetic dissolved oxygen concentrations to prevent anoxic release of phosphorus from the sediment to the water column. Mixing can also reduce cyanobacteria blooms through a number of factors that include light limitation because of increased residence depth as well as damaging the cyanobacteria with large changes in hydrostatic pressure. There are a number of techniques used to implement artificial mixing that include: 1) mixing with diffused air; 2) downdraft pumping; and 3) updraft pumping. Determining which technique to implement is challenging because of the wide range of configurations that exist in commercially available systems and the varying claims concerning the performance of these systems.

This presentation will discuss analyses that quantify the effectiveness of different mixing systems. The effectiveness of diffused air circulation is analyzed by coupling a near-field discrete bubble model with CE-QUAL-W2 to understand the far-field effects. A downdraft pumping system is analyzed by coupling a near-field jet model with CE-QUAL-W2. The effectiveness of each approach is quantified by summarizing model results in metrics that include hypolimnetic DO enhancement and thermal structure in the lake. This approach provides a general means to compare the performance of various mixing techniques on an analytical basis to help clarify which system provides the most cost-effective mixing.