Presentation Abstracts

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Interactive Sessions

Interactive Session A1: Ecosystem Valuation

November 16, 2021 | 2:00 pm – 3:30 pm EST

Dollar Benefit of Removal of Dead Zones in Lakes, Reservoirs, and Oceans

Alex Horne
University of California, Berkeley, California

As usual with catchy phrases, oceanographers coined “Dead Zones” to describe large areas of ocean bottom waters that have become anoxic in the Anthropocene. Nonetheless, freshwaters have dead zones and the public experiences them more than the marine ones. Most dead zones are a result of increased algal growth and decay usually due to increases in nutrients. Lake managers can fix anoxic bottom waters the methods ranging from direct oxygen addition or aeration and indirect techniques, algae reduction via alum, watershed changes, and others. But these methods cost money so in order to achieve a positive benefit/cost ratio, the value of dead zones needs to be assessed. Here I discuss two values: fish and house prices near water. For some places with chinook salmon dead zone removal values are high, for ocean shrimp not so much. The cost/benefit analysis, if done without political shenanigans can logically prioritize dead zone removals. Also, maybe the Dead Zone song.

*Examining Implicit Price Variation for Lake Water Quality

Kristen Swedberg[1], Kevin Boyle[1], Joseph Stachelek[2], Nicole K. Ward[3], Weizhe Weng[4], and Kelly M. Cobourn[5]
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Hedonic models are commonly used to estimate implicit prices for water quality in housing markets specific to small regions within a state. Recent studies use a scaled-up approach, aggregating sales across large spatial areas in a single scaled-up model. However, there is concern that these scaled-up models may overlook regional heterogeneity in water-quality preferences. Our study addresses this concern by examining how implicit prices for water quality vary across large geographic areas and testing whether a single hedonic model is suitable for estimating water quality preferences with sales from multiple states. First, we estimate a scaled-up hedonic model comprised of sales from multiple states and observe how the results change as we remove states from the model. We then estimate hedonic models for individual states and subregions within states and compare the resulting implicit prices for water quality. We find that the scaled-up model results are driven by select subregions and water quality preferences vary regionally within a state. The results of this study call into question hedonic models using data for large geographic regions where substantial differences may arise across housing markets.

Stakeholder-Driven Applied Research Coordination for the Protection of North Georgia's Water Supply: The Lake Lanier Watershed 5-Year Research Plan

Kristan VandenHeuvel[1] and Steve Leo[2]
[1]The Water Tower, Buford, Georgia; [2]Constantine an Ardurra Company, Buford, Georgia

Communities surrounding Lake Lanier rely on it for both drinking water and discharge of treated effluent, which requires coordinated planning, monitoring, management, and funding of applied water research projects to benefit Lake Lanier and its watershed. The Water Tower, a new nonprofit water innovation hub in Georgia, recently led an effort to create a 5-year research plan for the Lake Lanier Watershed. Stakeholders and researchers worked together to identify questions and concerns common to Lake Lanier water resource management stakeholders. A group of technical experts were engaged to design applied research project concepts that, when implemented, would assist in answering these stakeholder questions on topics including nonpoint sources, stormwater, nutrients, water quality and monitoring, land use, policy, outreach, and reuse.

This effort was completed against the background of a recently adopted Lake Lanier Chl-*a* total maximum daily load, growing development pressures, concerns about taste and odor, questions about the adequacy of existing monitoring efforts, and a desire to verify load assumptions associated with nutrient sources. By prioritizing the issues and building consensus, it is anticipated that stakeholders will be better positioned to secure funding, implement the applied research projects, and obtain desired real-world answers.

This presentation will review the approach taken to plan development, introduce the prioritized applied research project concepts, and discuss the approach that will be utilized to fund and implement the plan.

Interactive Session A2: Watershed Planning

November 16, 2021 | 2:00 pm – 3:30 pm EST

Prioritizing Lakes for Protection and Restoration in Watershed Planning

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Minnesota has adopted a watershed approach to restoring and protecting water quality. Funding to accelerate efforts to restore impaired waters and to protect unimpaired waters is awarded to local governments on a major watershed (HUC8) basis after completing a watershed planning process called One Watershed, One Plan. This planning effort requires prioritizing resources, targeting project locations, and measuring results. In a lake-based watershed, it can be difficult to prioritize where to work and to communicate the reasons for those priorities with lake associations and local residents. We have developed and applied a prioritization process that considers numerous criteria to prioritize lakes for both restoration and protection. This prioritization process can narrow down hundreds of lakes to approximately five to ten lakes in which to focus implementation efforts and funding. Criteria are tailored to the individual watershed based on its risks and qualities such as lake phosphorus sensitivity, shoreline development classification, dock density, presence of biologically significant fish and plant species, and water quality trends. In our experience it is most effective to choose just three to four criteria so that the prioritization can be communicated transparently in the plan and to lake associations and residents. Numerous examples of lake prioritizations in different types of watersheds such as forest-dominated and agriculture-dominated watersheds will be provided.

Looking for Loads in All the Right Places – A Decision-Making Framework for Watershed BMP Prioritization

Charles Ikenberry[1], Michelle Balmer[2], Katie Ansong[1], and Mark Jacobs[1]
[1]FYRA Engineering, Des Moines, Iowa; [2]Iowa DNR, Des Moines, Iowa

Nonpoint source pollution is a leading cause of water quality impairment and sediment deposition in lakes. Ideally, load reductions would be obtained through voluntary implementation of BMPs on private lands that often comprise a substantial majority of the surrounding watershed. However, limited landowner interest frequently limits load reduction opportunities on private land and restricts implementation to publicly owned lands adjacent to lakes. This situation increases the need to optimize the size, number, type, and location of practices implemented to improve water quality, comply with water quality standards, and meet TMDLs.

This presentation describes a quantitative approach to BMP prioritization to optimize sediment and phosphorus load reductions while minimizing the cost per pound of pollutant treated. The methodology builds upon trapping efficiency concepts developed by Brune (1953), Heinemann (1981), and Verstraeten and Poesen (2000). The prioritization model considers sedimentation rate, trapping efficiencies, lifespan, and construction bid prices. Trapping efficiency of multiple BMP configurations was drawn from literature using both empirical and case study data. Lake restoration efforts in Iowa indicate that pollutant reduction costs vary widely across potential sites, ranging from $30/lb-P/year to over $2,000/lb-P/year, which highlights the importance of designing for trapping efficiency, drainage area treated, critical source areas, and minimizing annualized construction costs. The methodology also integrates uncertainty of treatment efficiency and costs into BMP prioritization. The practical value of this model is the formulation of design and siting thresholds to more quickly screen and select watershed BMPs for lake restoration projects.

Choose Your Own Adventure: Successful Communication for Adaptive Watershed Management

K. Kelly Close and Carolyn Nobel
LRE Water, Denver, Colorado

Complexity, diversity, and the sheer volume of information can make watershed management and water quality data analysis intimidating and difficult to understand. We will demonstrate interactive web-based tools and techniques we have successfully implemented to engage stakeholders, provide a common ground for discussion of watershed and water quality issues. These tools turn data into accessible and usable information and empower users of all backgrounds to hone in on what matters to them. Focused "Story Pages" convey big picture insights and are powerfully combined with "Drill-down" tools that dive into the details. We will also highlight how these "Choose Your Own Adventure" systems can be leveraged to communicate to a wide range of audiences and promote transparency and accessibility of data.

Guardians of the Grand; Involving Citizens in Watershed Protection During a Pandemic

Jeri Fleming
Grand River Dam Authority, Langley, Oklahoma

In the fall of 2019, the Grand River Dam Authority, which is a conservation and reclamation district for one of Oklahoma's premier recreational lakes, received an environmental education grant from the Environmental Protection Agency. The purpose of the grant is to implement a watershed education program called Guard the Grand throughout the Grand Lake O' the Cherokees watershed. The program's goals are to foster an ethic of environmental stewardship by education and involving residents, teachers, students, and businesses by holding workshops, trainings and encourage them to become Guardians of the Grand.

Moving in to 2020 the program goal was to hold several workshops for teachers, residents and businesses as well as speak to community groups throughout the watershed. In March of 2020 everything could have been put on hold, but instead program staff came together to re-think how program goals and milestones could still be met. This presentation will discuss how staff adapted to continue to reach its target audience and move the program forward. The presentation will highlight challenges, successes and lessons learned of navigating public outreach and education through a global pandemic and come out on the other side without losing momentum.

** Student Presenter*

Interactive Session A3: Internal Loading

November 16, 2021 | 2:00 pm – 3:30 pm EST

Sediment Nutrient Release – It's Not Just for Eutrophic Lakes! Implications for Surface Water Restoration

Harvey Harper
Environmental Research & Design, Inc., Orlando, Florida

Benthic nutrient release is often the most significant source of nutrient loadings to eutrophic lakes, although it is often ignored in lake restoration plans and TMDL documents. However, sediment nutrient release occurs in all lakes, even oligotrophic waterbodies, and contributes loadings of both nitrogen and phosphorus. Data from nutrient release experiments and nutrient budgets were evaluated from 40 Florida lakes, ranging from oligotrophic to hyper-eutrophic, to characterize typical release rates for oligotrophic, mesotrophic, eutrophic, and hyper-eutrophic lakes. In general, sediment nutrient release increases with trophic status, and sediment release of both nitrogen and phosphorus is a significant part of the nutrient loading, even in oligotrophic waterbodies. Nutrient loadings from sediment nutrient release often exceed runoff loadings in Impaired Waters, and in most cases, water quality goals cannot be achieved by treating runoff only. Although management plans typically focus on external loadings, sediment inactivation alone can often achieve water quality goals at a substantially lower cost.

Sediment Nutrient Hot Spots in Minnesota Lakes and Ponds

Katie Kemmitt, Anne Wilkinson, and Jeff Strom
Stantec Inc., Minneapolis, Minnesota

Lake sediment chemistry has long been viewed as a critical component of nutrient cycling in lakes, in particular because of its relationship to internal phosphorus loading. Stormwater pond sediment chemistry has only recently emerged as a research focus, as the functionality of stormwater ponds in treating runoff has become a priority for stormwater management.

Sediment cores are routinely collected for physical and chemical characteristics from lakes and ponds, usually as a component to internal loading studies. Stantec has collected sediment cores from over 30 Twin Cities metro area stormwater ponds and 100 lakes across the state of Minnesota. Our dataset showed similar median phosphorus release rates among lakes and stormwater ponds. Stormwater ponds had lower median iron-bound, loosely bound, and labile organic phosphorus concentrations. Results from this meta-analysis will further identify trends in sediment phosphorus across lakes (shallow and deep) and ponds. Results may inform internal loading hot spots within Minnesota, similarities/differences between lakes and stormwater ponds, diagnostics, and management.

Internal Loading Driving Eutrophication in Lake Buchanan Reservoir, Texas

Alan W. Groeger[1] and David Bass[2]
[1]Aquatic Resources, Department of Biology, Texas State University, San Marcos, Texas; [2]Lower Colorado River Authority, Austin, Texas

Lake Buchanan, a warm monomictic hardwater reservoir on the Colorado River (Texas) has becoming increasingly more eutrophic since about the year 2000. The large watershed (47,580 km^2) which lies to the west is arid or semiarid, and therefore land use and human population has been fairly static for decades. It appears that the increasing productivity has been largely driven by internal loading of hypolimnetic phosphorus (P) and ammonium late in the growing season. We explore the relationship of causes and symptoms of the loading, including increasing concentrations of ammonium, phosphorus, CO_2, organic carbon, and alkalinity. The P loading is highly correlated with dissolution of $CaCO_3$ from the sediments. Annual variability in water residence time (including major floods and droughts), initiation and set-up of stratification in the spring and other "unique" events in the watershed help to understand these dynamics over the 34-year record.

Cyanobacteria Bloom Prevention in Two Connected Drinking Water Reservoirs

Gertrud Nürnberg
Freshwater Research, Baysville, Ontario, Canada

The drinking water of Moncton, New Brunswick, depends on two reservoirs. The upstream reservoir (feeding the downstream reservoir with the water withdrawal since 2014) experienced a potentially toxic cyanobacteria bloom in the fall of 2017. Both reservoirs are relatively unproductive (upstream: meso-eutrophic, 0.017 mg/L total phosphorus, TP; downstream: oligotrophic, 0.008 mg/L TP) but experience oxygen depletion (< 3.0 mg/L DO) every summer (anoxic factor of 21 d/yr and 9 d/yr).

Phosphorus and metal depth profiles, their seasonal changes, and sediment P fractionation indicate internal P release from anoxic sediment in 3 of the 4 study years. Since 2017, internal load was up to 28% of total TP load in the upstream and up to 12% in the downstream reservoir. Phosphate released from bottom sediments can present a nutrient source for cyanobacteria growth in late summer and fall. Therefore, a lake treatment plan that prevents potentially toxic cyanobacterial blooms includes the direct treatment of P release with the phosphorus binding material lanthanum (Phoslock), as well as a physical management approach.

The physical approach involves the increase of the upstream dam height and is based on theoretical limnological considerations and TP mass balance modeling. The heightening of the water level in conjunction with the management of deep-water outlets is expected to create conditions less favorable to cyanobacteria. A larger epilimnion would discourage surface blooming cyanobacteria (Dolichospermum) in favour of more beneficial algae genera, which outweighs concerns respective increased hypoxia, metalimnetic cyanobacteria proliferation (Planktothrix), and increased P export downstream.

Interactive Session A4: Remote Sensing

November 16, 2021 | 2:00 pm – 3:30 pm EST

Identifying Frequency of Cyanobacteria Events in Lakes and Chlorophyll *a* Endpoints Using Satellite Estimates of Cyanobacteria Concentration

Rebecca Veiga Nascimento[1], Michael Paul[2], Mark Fernandez[2], and Monty Porter[1]
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Many Oklahoma lakes are nutrient rich and exhibit poor water quality due to high algal biomass, low dissolved oxygen, and harmful algal blooms (HABs). HABs are known to occur across the state; however, there is no consistent information on the location, timing, and frequency of HABs in Oklahoma lakes. The US EPA CyAN Project produces weekly satellite observations of cyanobacteria abundance; this data was used to calculate average frequency of high cyanobacteria (> 100,000 cells/mL) events in 53 satellite resolvable lakes. Approximately half of the lakes were observed to have high cyanobacteria events at least 40% of the time. Additionally, the satellite observations of cyanobacteria were used in combination with various measures of watershed function to build a predictive model of high cyanobacteria event frequency for 78 additional lakes not resolvable by satellite. The final model was able to explain 77% of the variation between observed high cyanobacteria events and predicted high cyanobacteria events. The model projected high cyanobacteria events at a frequency of 40% or greater for approximately half the lakes in the non-resolvable population. The frequency of high cyanobacteria events was related to measured lake chlorophyll *a* concentrations. As chlorophyll concentration increased, the probability of a high cyanobacteria event also increased. A chlorophyll *a* concentration of 10 µg/L related to a 16% probability that the frequency of high cyanobacteria events would be greater than 35%. These analyses highlight the opportunity for water quality management actions to restore and protect Oklahoma lakes from cyanobacteria blooms.

Developing Satellite-Derived Algal Monitoring Tools for Lakes – Collaboration Among Academia, Government, and Environmental Non-government Organizations in Alberta

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With increased attention on Harmful Algal Blooms (HABs) in freshwater systems, there has been a surge in remote-sensing techniques developed to monitor HABs. Remote sensing offers unique advantages to traditional techniques, such as the ability to visualize high resolution spatial and temporal variability of HABs, enabling a better understanding of HAB dynamics. We established a working group to develop a satellite-derived algal monitoring tool for a large recreational lake in central Alberta. In the summer of 2020, 100 phytoplankton samples were collected to validate satellite-derived algal abundance using Sentinel-2 and Sentinel-3 satellites, with an initial focus on chlorophyll *a* concentration. An interactive, near real-time tool using Google Earth Engine was developed using these data. Current research focuses on validating the tool for use in other lakes in Alberta, exploring the use of taxonomically diagnostic pigments and total cells counts in ground-truthing remote-sensing estimates of HABs. The goal of the working group is to support research into the dynamics of HABs on Alberta lakes, contribute to environmental public health monitoring of HABs, and to provide tools that enable watershed stewardship groups and government to evaluate lake management initiatives.

Spatial/Temporal Trend Analysis of 10,000+ Minnesota Lakes Using Satellite Derived Water Quality Data From an Automated High Performance Computing Environment

Leif Olmanson, David Porter, Jeffery Peterson, Marvin Bauer, and Patrick Brezonik
University of Minnesota, St. Paul, Minnesota

Using Landsat imagery, we have assessed lake water clarity in Minnesota, USA for over 20 years. For early assessments we used empirical methods and in situ Secchi calibration data. Recent advances in satellite technology (improved spectral, spatial, radiometric, and temporal resolution) and atmospheric correction, along with cloud and supercomputing capabilities, have enabled development of automated regional-scale measurements of water quality. These new capabilities provide opportunities to improve lake and fisheries management by measuring more variables (chlorophyll, colored dissolved organic matter (CDOM) and total suspended matter, the main determinants of water clarity) more frequently. Combining these new capabilities with earlier assessments, we create a 35-year (1985–2020) satellite-derived late summer water clarity database for long-term trends. To explore seasonal patterns, we created monthly water quality (clarity, chlorophyll, CDOM) data using all available May–October Landsat 8 and Sentinel 2 imagery from 2015 to 2020 for 10,000+ lakes. These maps and auxiliary data were used for spatial/temporal analysis to explain regional differences in water quality. Areas dominated by forests/wetlands had higher water clarity than agricultural and developed areas and shallower lakes had lower clarity than deep lakes with similar land cover. Changes in water clarity were attributed to changes in land use and climatic factors. Clarity increased in many urban lakes which was attributed to BMPs and development of agricultural fields. Clarity decreases were attributed to changes in precipitation, temperature, and crop types. Differences in CDOM were related to precipitation and predominant land cover, with wetland/forested area associated with higher CDOM than agricultural areas.

Lake Observations by Citizen Scientists and Satellites: Validation of Satellite Data to Support Hydrologic Science

Grant Parkins[1], Tamlin Pavelsky[1], Sheikh Ghafoor[2], Faisal Hossain[3], Sarina Little[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. Automated monitoring of even 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 Observations by Citizen Scientists and Satellites (LOCSS) project has engaged more than 2700 citizen scientists in monitoring lake levels. This data is combined with lake surface area measurements derived from Landsat 8 and Sentinel 2 satellites, to understand how lake volume changes over time. We have found that citizen scientists provide accurate lake level data, with a mean absolute error of 1.6 cm.

LOCSS is studying more than 120 lakes in the US, France, India, and Bangladesh. We determined the correlation of volume changes between lake pairs within these regions. These pairs are, on average, significantly correlated, though many pairs remain uncorrelated. In some regions (but not others) we found that distance between lakes predicts correlation, suggesting that both local and regional factors are influencing variations in lake storage.

New LOCSS initiatives include: 1) Growing our network of lakes both within the US and internationally; 2) Developing a prototype smart phone app for measuring inundation extent; and 3) Using new and existing data to evaluate satellite water level measurements from the current suite of nadir altimeters and the upcoming SWOT satellite mission.

Interactive Session B1: Modeling

November 16, 2021 | 4:00 pm – 5:30 pm EST

Three-Dimensional Modeling of Eutrophication and Cyanobacteria Growth in Two Shallow Bays of Lake Champlain

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[1]Water Quality Solutions, McGaheysville, Virginia; [2]University of Vermont, Burlington, Vermont

Lake Champlain is a large, transnational lake located in the northeastern United States and Quebec. The eastern bays of Lake Champlain have experienced increased eutrophication and cyanobacteria blooms over the last century. This has led to significant interest in understanding the factors driving eutrophication and cyanobacteria growth in the lake.

In this work, we present calibration of a three-dimensional water quality model for the eastern portion of Lake Champlain using AEM3D with emphasis on Missisquoi Bay and St. Alban's Bay, two shallow bays that have experienced water quality concerns. The model performance was evaluated against biochemical and physical data from years 2017–2019. Modeling results suggest a number of factors have led to eutrophication of the shallow bays, including internal loading despite the typically high measured dissolved oxygen levels at depth. This water quality model provides a framework to couple with hydrology, climate, and land-use models to run 100-year simulations that investigate the effects of future climate and land-use scenarios on water quality in the eastern bays of Lake Champlain.

Assessing Treatability With Lake Drawdown

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

The Lower Colorado River Basin has experienced a significant drought between 2000 and the present. At lower Lake Mead levels (below 1075 ft above sea level), the thermal structure, water movement, and water quality may change significantly, which could affect drinking water treatment requirements, aquatic ecosystems, and water quality in the Lower Colorado River in Lake Mead and downstream of Hoover Dam. A decrease in water level can cause higher water temperature, increased suspended sediment movement and concentrations, and elevated organic matter loading, which could require changing drinking water treatment process or plant expansions. Water quality changes in Lake Mead will be transmitted downstream through Hoover Dam and will likely affect Lake Mohave and Lake Havasu, which could require changes in operations for downstream water users. This study will evaluate and plan the development and expansion of SNWA Treatment Processes and will be a valuable resource for impact studies on the fragile aquatic ecosystems in Lake Mead and other lakes of the Colorado River System. This study uses a two-part modeling approach to assess treatability of drinking water withdrawn from a newly constructed drinking water intake located in Lake Mead, Nevada, USA. The water quality modeling results provide information related to water quality changes that will inform the drinking water treatment modeling, will lead to changes in water quality and habitat utilized by aquatic organisms in Lake Mead and the quality of water released from Hoover Dam to downstream users and ecosystems.

Updating a Water-Quality Model of Lake Mead to Support Salinity Modeling on the Colorado River

Kevin Bierlein[1], Nicolás Rodríguez-Jeangros[1], Steve Setzer[1], and Hong Nguyen-DeCorse[2]
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The Colorado River is a highly-managed river system that provides water to seven US states and Mexico. One agreement that guides operations in the basin is International Boundary and Water Commission Minute No. 242, which sets limits on the annual average salinity differential between water arriving at Imperial Dam and water arriving at the Northerly International Boundary (NIB) with Mexico. The US Bureau of Reclamation uses a RiverWare model to forecast the annual salinity differential and inform decision making regarding river operations with respect to Minute No. 242 compliance.

In an effort to improve these forecasts, an existing CE-QUAL-W2 model of Lake Mead was updated and recalibrated to provide predictions of salinity in water released from Lake Mead. These predictions would support the RiverWare model and allow for salinity forecasts to span from Lake Mead to the NIB. Several refinements were made to the Lake Mead model, and the model was recalibrated to recent observed data. These improvements reduced the model error by ~25% and highlight the benefit of periodically updating models as additional data are collected or the intended use of the model changes.

Beginning in 2020, the improved Lake Mead model has been used to provide quarterly forecasts of salinity in outflows from Lake Mead. The updated model has improved predictions of the salinity differential by reducing uncertainty in salinity forecasts at the upstream end of the RiverWare model.

Interactive Session B2: HABs – Case Studies 1

November 16, 2021 | 4:00 pm – 5:30 pm EST

Monitoring and Management of HABs in New Jersey Waterbodies From 2019 to 2021

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As a result of unprecedented Harmful Algal Blooms (HABs) that plagued recreational waterbodies and potable water supplies throughout New Jersey in 2019, existing monitoring protocol was revised by the New Jersey Department of Environmental Protection (NJDEP) to address these conditions. Cyanobacteria cell counts were originally identified as a surrogate for the potential presence for cyanotoxins during a HAB event. However, in order to provide more timely information on making site-specific management decisions, measurements of the auxiliary pigment phycocyanin were also employed to assess the potential for HABs. NJDEP also revised their Action Alert Level responses to HAB events of varying magnitudes.

In response to the 2019 HAB events, a variety of innovative, near-shore in-lake and watershed-based management measures were funded, implemented, and evaluated as ways of controlling, mitigating, and possibly preventing HABs. These projects were conducted over the 2020 and 2021 growing seasons and included the use of alternative nutrient inactivators and algaecides, as well as Floating Wetland Islands, various types of near-shore aeration / circulation, the use of Biochar in various capacities and the installation of rain gardens. This presentation will provide an evaluation of these various management measures.

Algal Blooms in Ontario, Canada: Continued Increases in Reports Through the 21st Century

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[1]Queen's University, Kingston, Ontario, Canada; [2]Ontario Ministry of the Environment, Conservation and Parks, Environmental Monitoring and Reporting Branch, Toronto, Ontario, Canada; [3]Ontario Ministry of the Environment, Conservation and Parks, Dorset Environmental Science Centre, Dorset, Ontario, Canada

The Ontario Ministry of the Environment, Conservation and Parks provides an algal identification service in response to public reports of suspected algal bloom events, which have been tracked since 1994. In a previous analysis, Winter *et al*. (2011) noted a significant increase in the number of reports of confirmed algal blooms from 1994 – 2009, and especially pronounced was an increase in the number of blooms in which cyanobacteria were the dominant taxa. Here, we determined that this increasing trend in the yearly number of confirmed cyanobacterial bloom reports has persisted over the past decade, to 2019. Additionally, the increase in the length of the yearly bloom reporting period noted in Winter *et al*. (2011) has continued, with blooms being reported earlier in the summer and later into the fall. Over half of the reported cyanobacterial blooms came from lakes on the Canadian Shield, in the Georgian Bay (5E) Ecoregion, known for cottaging. Data from the Ontario Lake Partner Program was used to investigate total phosphorus (TP) concentrations in lakes with confirmed reports of cyanobacterial blooms. Approximately 41% of the bloom lakes had average spring TP concentrations less than 10 µg/L, compared to a median value of approximately 8.5 µg/L for Lake Partner Program lakes with no reports of blooms, or no confirmed cyanobacteria blooms. Adding an additional decade to the dataset presented by Winter *et al*. (2011), we analyze the confirmed blooms by dominant taxa and geography and discuss the role of natural and anthropogenic factors in rising bloom reports.

Response to Harmful Algal Blooms in Arkansas: A 3-Year Review

Brianna Olsen
Arkansas Division of Environmental Quality, North Little Rock, Arkansas

In 2017, the Office of Water Quality at the Arkansas Division of Environmental Quality (DEQ) was awarded an EPA Monitoring Initiative Fund (MIF) Grant to investigate harmful algal blooms (HABs). Historically there had been no documented cases in Arkansas, so in 2014 when a large bloom was reported on a popular lake in the height of the summer, it became clear that there was a need for a better understanding of why and how these events occur. Since that time, DEQ created a workgroup of water quality experts around the state to help develop the HAB Response Plan, released in December 2019. The Response Plan, while developed through the input of the workgroup, was also informed by data collected through the MIF Grant. Six lakes were selected that met susceptible criteria as advised by EPA (*i.e.*, history of HABs or nutrient loading, morphology, water body use). Although some of the lakes selected did experience blooms, one of the most beneficial aspects of the project was the ability to analyze cyanotoxins in-house, develop an online reporting tool, and attend meetings around the state informing partners and citizens of the developing program. Due to information collected through the online reporting tool and workgroup partners, DEQ was able to collect data for several additional blooms on twelve lakes and one river not previously monitored or selected for HAB sampling. This new information has allowed DEQ to be more strategic about which water bodies are routinely sampled to better identify bloom-forming trends.

Toxic Algae Gone Wild

David Buzan
Freese and Nichols, Inc., Austin, Texas

Texas was the epicenter of toxic golden algae, *Prymnesium parvum*, kills beginning in the late 1970s. Since the first confirmed golden algae kill in 1986, fish kills attributed to this toxic haptophyte have since spread throughout much of the continental US. Toxicity attributed to the filamentous blue-green algae, *Microcoleus*, has killed pet dogs in Lady Bird Johnson in Austin, Texas in recent years. Within the last year, the 24-year mystery killer of bald eagles, coots and waterfowl in the southeastern US was revealed. A cyanobacteria (blue-green algae), *Aetokthonos hydrillicola*, that grows on the invasive aquatic plant, *Hydrilla*, produces a toxin which when consumed by waterfowl (or eagles feeding on the waterfowl) creates brain lesions. Freese and Nichols, Inc. has provided microscopic analysis of water samples for golden algae for private pond and lake owners for the past 7 years. Many of these lakes are fed by brackish groundwater which is salty enough to support golden algae. Lessons learned about different algal controls, ex. fertilization, and questions about transmission have been raised over during these years. A new question has arisen over the occurrence of the filamentous blue-green algae, *Raphidiopsis curvata*, in many of these ponds experiencing fish kills in the absence of golden algae. *R. curvata* is known to cause toxicity and we begin to wonder if some fish kills suspected of being caused by golden algae may actually be caused by *R. curvata*.

Interactive Session B3: Biodiversity

November 16, 2021 | 4:00 pm – 5:30 pm EST

*Shifting Baselines: Fish Presence Reduces Food Web Stability by Altering Consumer Diet Composition

Katherine Low and Jim Haney
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Commonly viewed as barren, sub-par habitat, fishless lakes worldwide have been stocked to enhance recreational fishing opportunities. Fish introductions have well-defined direct effects on the diversity and abundance of zooplankton, amphibians, and waterbirds. However, the indirect effects of fish on food web interactions are poorly understood. Here, we aim to characterize the structure of fish and fishless lake food webs in northwest Wyoming. Surveys and sampling were used to identify zooplankton, macroinvertebrate, amphibian, fish, and waterbird communities of seven lakes with fish and five lakes without fish. Stable isotope analysis was used to identify diet composition of each species. Community metrics were then used to evaluate the stability of these food webs. Overall, we found that the presence of fish altered the plankton community but had little effect on the species composition of macroinvertebrates, amphibians, or waterbirds. However, fish presence significantly altered the diets of all other consumer groups, including invertebrates, frogs, and Common Loons. We found that consumers in fishless lakes relied on a greater diversity of food sources (stemming from littoral, pelagic, and benthic sources) compared to consumers in lakes with fish, which relied mostly on pelagic energy sources. As a result, consumers in lakes with fish occupied significantly less trophic niche space, which is associated with a reduction in food web stability. Reduced food web stability is expected to increase the susceptibility of these systems to invasive species, climate change, and other stressors.

*Freshwater Mussels and Clean Water Regulation in Minnesota: The Importance of Water Quality Standards in Sustaining Ecosystem Services by Protecting Mussels

Baishali Bakshi[1], Will Bouchard[1], Daniel Hornbach[2], Bernard Sietman[3], and Dennis Wasley[1]
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Freshwater mussels are threatened with extinction in North America. They are a sentinel species for ecosystem function and contribute substantially towards many ecosystem services. Ecosystem services being essential for human well-being, there is a need to protect freshwater mussels both for conserving the species and for sustaining the flow of ecosystem services for current and future generations. As mussels require clean water to survive, and since conserving ecosystem services is implicit in the federal Clean Water Act, incorporating mussel conservation into clean water goals could serve multiple conservation goals. Yet current clean water regulation is not sufficiently protective of mussels. In this paper we synthesize information on the status of freshwater mussels, their contribution to ecosystem services, threats to their conservation, and gaps between their water quality requirements and current water regulation, to help inform clean water and conservation goals in Minnesota.

Aquatic Community Surveys in Lake Elsinore, California With Recommendations for Fisheries Management

Nathan Jahns[1], John Rudolph[2], Chris Stransky[2], and Kevin Stolzenbach[2]
[1]GEI Consultants, Inc., Denver, Colorado; [2]Wood Environment and Infrastructure Solutions, Inc., San Diego, California

Lake Elsinore is a natural, 3,000 acres lake in Southern California. Lake Elsinore has historically been a terminal lake, with outflows occurring only rarely. The condition of Lake Elsinore under natural circumstances has varied significantly over the last 100 years in response to dry and wet climatic periods affecting the expanse and depth of the lake. Lake level stabilization is being addressed through recycled water additions to the lake. However, given the naturally variable climatic conditions coupled with impacts from anthropogenic activities, the quality of the water (in particular salinity and nutrients), the resident biological community, and the opportunity for recreation in and on the lake can vary significantly. Water quality can also be impacted by carp as a result of foraging behavior that causes resuspension of sediments. This concern was previously addressed by a 2002–2008 carp removal program that successfully removed more than 1.3 million pounds of carp. To facilitate lake management planning discussions, a study to assess current conditions of the aquatic community in Lake Elsinore was implemented in 2019 and a fish survey (beach seining, purse seining, and trawling) was conducted. The findings from data collection efforts and an extensive literature review including historical phytoplankton and zooplankton populations in the lake were used to develop a fishery management recommendations report which included; (1) recommendations to improve the Lake Elsinore fishery and habitat to support efforts to improve water quality; and (2) determine the need for additional harvesting of fish to control nuisance species impacting water quality.

*Just Add Water: How Water Supply to One Reservoir Controls Water Quality and Fish Habitat Throughout the Henry's Fork Basin in Idaho

John McLaren[1], Rob Van Kirk[2], Soren Brothers[3], Phaedra Budy[4], and Melissa Muradian[2]
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Increased drought frequency due to climate change puts pressure on water supply and storage reservoirs, with uncertain effects on the economically important fisheries upstream, within, and downstream of reservoirs. Island Park Reservoir, a mid-sized hypolimnetic-release water storage reservoir on the Henry's Fork River in Idaho, supports a community of adfluvial salmonid sportfish but is subject to high and more frequent drawdown during drought cycles. Utilizing a combination of long-term abiotic and fisheries monitoring, we sought to understand mechanisms connecting water supply and storage with upstream, in-reservoir, and downstream water quality and fish habitat. We hypothesized that increased drawdown volume from water supply shortages would reduce water quality and fish habitat throughout the river-reservoir system. We found Island Park Reservoir's physical characteristics and limnology interacted with drawdown to negatively affect in-reservoir and downstream water quality, including increased average water temperatures, increased sediment delivery, and decreased dissolved oxygen concentrations. Water supply also negatively impacted fish habitat and populations throughout the river-reservoir system. Downstream, drawdown reduced winter flows and subsequent trout recruitment. In the reservoir, drawdown increased temperatures and decreased oxygen concentrations, resulting in unsuitable conditions for kokanee salmon recruitment and reduced upstream spawning migrations. Future work includes understanding the specific mechanisms behind recruitment limitations associated with drawdown, as well as evaluating the ecological significance of adfluvial fish to reservoir tributaries. Results from our research are already in use; fisheries and agricultural interests are exploring collaborative programs to improve irrigation management and reduce irrigation water delivery and resulting drawdown at Island Park Reservoir.

Interactive Session B4: Citizen Science 1

November 16, 2021 | 4:00 pm – 5:30 pm EST

NALMS Secchi Dip-In Information System: Project Update, System Navigation, How-Tos, Tricks, and Tips

Mark LeBaron
Gold Systems, Salt Lake City, Utah

Abstract Text

*A Collaborative Approach to Upgrading the NALMS Secchi Dip-In Database and Improving Data Flows Using AWQMS and the Lake Observer App

Leah Hicks[1], Lisa Borre[2], Julie Chambers[3], Philip Forsberg[1], Perry Thomas[1], Alyssa Anderson[1], Chris Adams[3], Michael Forcella[2], Kathleen Weathers[2], Kayla Gower[4], Alex Heppner[4], Ryan Jorgenson[4], and Mark LeBaron[4]
[1]North American Lake Management Society, Madison, Wisconsin; [2]Cary Institute of Ecosystem Studies, Millbrook, New York; [3]Oklahoma Water Resources Board, Oklahoma City, Oklahoma; [4]Gold Systems, Salt Lake City, Utah

The Oklahoma Water Resources Board (OWRB) was awarded a USEPA Exchange Network grant that included funding to work in partnership with the North American Lake Management Society (NALMS). OWRB and NALMS have been working together to provide a long-term solution for Secchi Dip-In data management using the Ambient Water Quality Monitoring System (AWQMS) while simultaneously providing the Global Lake Ecological Observatory Network (GLEON) Lake Observer mobile app for project partners and the AWQMS community. The goal of this project is to provide a long-term solution for Secchi Dip-in data management, validation, sharing and flow to both the US governments' Water Quality Exchange (WQX) and the Water Quality Portal (WQP). This project has facilitated the development of methods used for data submission and management within AWQMS and the Lake Observer app; including spreadsheet templates for formatting data, web-based data entry forms, allowing citizen scientists to directly enter and upload their results into AWQMS, and improving the connection between AWQMS and the Lake Observer app to allow for bulk uploads of data. AWQMS also automatically consolidates all data submissions under one organization (NALMS) for easy submission to WQX and WQP. This project supports the growth of the Secchi Dip-In, and simultaneously increases the amount of water quality monitoring data that are publicly available through WQX and WQP. Project partners will present the results of this project from the past four years, provide a demonstration of data submission and visualization tools, and provide an update on the collaboration between OWRB, NALMS and GLEON.

Introducing Connecticut Lake Watch – The Northeast's Newest State-Led Volunteer Lake Monitoring Program

Meghan Lally and Tracy Lizotte
Connecticut Department of Energy and Environmental Protection, Hartford, Connecticut

Connecticut is home to more than 2,000 freshwater lakes, ponds and reservoirs. Public interest in lake water quality is rapidly expanding, particularly as algae blooms and invasive plant infestations (and the associated management costs) become increasingly problematic. For more than 20 years, the Connecticut Dept. of Energy and Environmental Protection (CT DEEP) Volunteer Water Monitoring Program has trained volunteers to conduct a variety of water quality monitoring activities, but until recently these activities focused almost exclusively on river and streams. Therefore, in spring 2021, in partnership with the Connecticut Federation of Lakes, CT DEEP launched its newest volunteer monitoring network - Connecticut Lake Watch. The initial intention was to develop a program to standardize volunteer monitoring, in order to better support State water quality assessment efforts. However, it quickly became apparent that flexibility was needed to accommodate the many varied local monitoring programs already in existence. This presentation will review the rapid development of the Connecticut Lake Watch program over the past 9-months. Of note, we will review the program's successful use of the Lake Observer app for data collection and management and highlight some unexpected partnerships and data flow improvements that have emerged as a result of this new initiative.

Lake Monitoring – Volunteers a Key for Effective Lake Management and Restoration

Elizabeth Herron
University of Rhode Island Watershed Watch, Kingston, Rhode Island

For more than thirty years volunteers in the URI Watershed Watch program have been monitoring lakes and ponds (as well as rivers, streams, estuaries, and salt ponds) throughout the state and adjacent areas. Scientist-led, state-certified and using established methods, the volunteer generated data have produced significant and robust long-term data sets that encourage local actions. This presentation will include a look at the overall Watershed Watch program, some monitoring results, how those data have fostered local actions, and highlight how volunteers continue to be an integral component of management and restoration projects.

Interactive Session C1: Technological Advances in Phytoplankton Ecology

November 17, 2021 | 12:00 pm – 1:30 pm EST

Comparison of Imaging Flow Cytometry and Manual Counts for Assessing Ecological Status and Harmful Cyanobacterial Bloom Monitoring

Ann St. Amand[1], Jennifer Graham[2], Lawrence Eichler[3], Guy M. Foster[2], Sabina R. Perkins[2], Cory Sauve[1], Denise Clark[1], and Hannah Schroeder-Larkins[1]
[1]PhycoTech, Inc., St. Joseph, Michigan; [2]US Geological Survey, Troy, New York; [3]Darrin Fresh Water Institute, Boston Landing, New York

Numerous sampling and analytical methods exist to assess ecological status and to monitor harmful cyanobacterial blooms (HCBs) in freshwater systems. Imaging flow cytometry presents a powerful tool for assessing phytoplankton assemblages as it reduces processing time when compared to manual counts while maintaining an intermediate level of taxonomic detail. This increased capacity and reduced processing time makes flow cytometry an effective method for HCB monitoring and large-scale ecological assessment. This presentation will compare manual counts and results from the Imaging Flow Cytobot (IFCB) for two projects in New York. Preserved and live samples from two lakes in the Finger Lakes region and preserved samples from one lake in the Adirondack region were included in the analysis, with 22 and 20 sampling events in each region, respectively. Each sample was analyzed using both manual counts and the IFCB. Comparisons between the manual and IFCB counts are analyzed using multidimensional scaling, specifically focusing on differences between functional groups, species classes, and critical water indicators such as HCB species. The differences between live and preserved samples are also compared.

*Growth and Ionome-Wide Responses of Phytoplankton to Relative Supplies of Nitrogen, Phosphorus and Trace Metals: From Chemostats to Grand Lake

Yetkin Ipek and Punidan D. Jeyasingh
Oklahoma State University, Stillwater, Oklahoma

Harmful algal blooms (HABs) are increasing in frequency and magnitude worldwide. To date, forecasting HABs rely on the relationship between algal growth and the supplies of energy and materials abundant in biomass (*e.g.*, nitrogen, phosphorus). However, we are far from predicting blooms with any certainty. In addition to materials needed for the organic framework, trace metals also play unique and important catalytic roles. Moreover, there is growing appreciation for correlated changes in the quotas of multiple elements encompassing an organism (ionome) when the supply of one element changes; indicating that growth differences arise from complex biochemical adjustments rather than limitation of key anabolic processes by one or two elements. Here we quantified the growth and ionomic response of a diazotrophic cyanobacterium, *Anabaena circularis* in varying conditions of N, P, and Fe supplies. We found strong effects of N:P as well as Fe supply on growth and ionome. Next, we quantified the frequency and abundance of HAB-forming taxa in four biogeochemically distinct locations in Grand Lake, Oklahoma (Horse Creek, Honey Creek, Duck Creek and Drowning Creek). At each site, dissolved concentrations of 12 elements, standing algal biomass, particulate concentrations of 12 elements, and relative abundances of phytoplankton were measured. Results revealed several correlated changes between the supplies of nutrients in the water column, and the yield and ionomes of phytoplankton. These results indicate that multiple elements encompassing the ionome of phytoplankton affect bloom formation, and the supplies of such elements may help improve the ability to forecast blooms.

Genomics of Aphanizomenon-Dolichospermum-Anabaena HABs in the US Pacific NW

Theo Dreher[1], Ryan Mueller[1], Ed Davis II[2], and Timothy Otten[3]
[1]Department of Microbiology, Oregon State University, Corvallis, Oregon; [2]Center for Genome Research and Biocomputing, Oregon State University, Corvallis, Oregon; [3]Bend Genetics LLC, Sacramento, California, and Department of Microbiology, Oregon State University, Corvallis, Oregon

Aphanizomenon flos-aquae, *Dolichospermum* and *Anabaena* cyanobacteria belong to a distinct group within the Nostocales that has been termed the ADA clade. ADA members are prominent and problematic components of toxic and non-toxic HABs worldwide, particularly in temperate regions. We have determined 16 ADA genome sequences, mostly from samples directly taken in recent years from major HAB events in Oregon. Phylogenomic analysis shows the ADA clade to be a discrete genus-level group that also includes *Cuspidothrix issatschenkoi*. The ADA clade is proposed to encompass 10 species, none of which corresponds to groupings of the currently used genus names. These observations show that close genetic relationships cannot reliably be inferred from morphology for these organisms. Our results indicate that ADA members in the Pacific NW often form blooms dominated by a single genotype and morphotype. However, ADA HABs in different Oregon lakes are typically caused by distinct strains, indicating a high level of genomic diversity. Among the new genomes were cylindrospermopsin and microcystin producers from Detroit Reservoir, Oregon, that are the presumed cyanobacteria responsible for a drinking water alert in the City of Salem during 2018. Several ADA genomes lack cyanotoxin genes, while others contain genes of high relevance to drinking water and public health authorities: biosynthetic genes for the production of microcystin, cylindrospermopsin, anatoxin-a and geosmin.

Interactive Session C2: Watershed BMPs

November 17, 2021 | 12:00 pm – 1:30 pm EST

Watershed Management Support System: A User Friendly Tool for Non-modelers to Link BMPs to Water Quality Outcomes

Mel Vargas[1], Kirk Dean[1], Darrell Townsend[2], Stephen Nikolai[2], William Mausbach[2], Michael Bukata[1], and Howard Shotz[1]
[1]Parsons Corporation, Austin, Texas; [2]Grand River Dam Authority, Langley, Oklahoma

Robust watershed and reservoir modeling exercises are time consuming, data intense, and require skilled personnel for proper execution. Water resource managers are often faced with implementation hurdles that include (1) identifying priority hydrologic units (HUCs) for BMP implementation, (2) understanding the potential outcomes of BMP implementation, and (3) evaluating different scenarios of BMP implementation on lake water quality metrics in a timely fashion. Grand Lake O' the Cherokees is a large reservoir located in northeastern Oklahoma and the terminus of runoff from approximately 10,000 mi^2 of watershed that originate in and flow across multiple state, federal, and tribal jurisdictions. Water quality issues continue to threaten the economic vitality of the region; thus, our goal is to develop a tool that allows us to rapidly identify sub-watersheds that disproportionately impact water quality in Grand Lake and to identify the most cost-effective BMPs for mitigating those water quality impacts. We accomplished this by integrating multiple SWAT watershed loading models and water quality response predictions from an EFDC reservoir model into a Watershed Management Support System (WMSS), a secondary computer application designed to provide a user-friendly interface for watershed managers to make informed watershed management decisions. The WMSS allows managers with limited modeling experience to easily select different HUC and BMP combinations within the Grand Lake watershed and quickly estimate the effects of those combinations on targeted water quality variables within Grand Lake.

Financial Interest Disclosure: The author(s) of this abstract has/have financial interest in the corporations, commercial products, methods, and trade or brand names described.

A Chickasaw-Led Initiative to Identify Land Suitable for Controlled Burns for Improving On-Farm Economics and Water Quality in the Arbuckle Lake Watershed

Kris Patton[1], Annabeth McCall[2], and Barney Austin[2]
[1]Chickasaw Nation, Ada, Oklahoma; [2]Aqua Strategies Inc, Austin, Texas

Invasive woody plant encroachment is known to have direct impacts on local hydrology, water quality, and nutrient cycling within a watershed. It also adversely impacts soil health and land available for grazing. Arbuckle Lake, in Murray County, Oklahoma, is a 2,350-acre reservoir currently on the state impaired water body list due to poor water quality standards. Within the Arbuckle Lake watershed, a grassland prairie ecosystem, invasive species such as eastern redcedar (*Juniperus virginiana*) has dramatically expanded its range in the watershed. The Chickasaw Nation has helped form a watershed stakeholder group (Lake of the Arbuckles Watershed Association – LAWA) and recruited other partners to help improve soil health in the watershed. This long-term project will involve identifying land parcels suitable for prescribed burns using a phenology-based algorithm applied to satellite data, while at the same time monitoring water quality, soil health and promoting other best land management practices. The economic benefits of the program will also be quantified by estimating increased yield from ranchers, and associated land values. This multi-year effort will ultimately lead to healthier soil and cleaner water within the watershed.

*Determining the Impacts of Grazing, Vegetation Cover, and Wildlife on Bacterial and Nutrient Concentrations of Surface Runoff

Austin Phillippe, Kevin Wagner, and Chris Zou
Oklahoma State University, Stillwater, Oklahoma

In semi-arid ecosystems, surface runoff from storm events is considered the primary source of water for reservoirs and streams. The inconsistency associated with runoff creates challenges when it comes to evaluating the health of these water resources. The goal of this project is to determine how grazing and vegetative cover impact *Escherichia coli* and nutrient contamination of surface runoff. At the Cross Timbers Experimental Range, we are collecting data on the water quality of runoff from ten experimental watersheds classified by dominant vegetation type and access to cattle. Consistent with past studies related to Ecohydrology, we have found greater amounts of runoff from grassland watersheds compared with forested watersheds. Preliminary results indicate that areas with access to cattle have larger *E. coli* and nutrient concentrations than those areas where cattle are excluded. Although the nutrient concentrations are greater in watersheds where grazers are present, these concentrations are not above EPA recommendation levels for primary body contact. However, the surface runoff from watersheds with and without access to grazers both have *E. coli* contamination significantly greater than the EPA recommendation. Camera trap data was assessed to determine wildlife presence based on vegetation cover characteristics of the watersheds to quantify this impact. The conclusions of this thesis project will address wildlife impacts on surface water quality and assist land managers in targeting areas susceptible to contamination.

Cyanobacteria Management in Agricultural Watersheds Using Conservation Management Practices

Richard Lizotte, Lindsey Yasarer, Martin Locke, and Matthew Moore
USDA-ARS, Oxford, Mississippi

Intensive row-crop agriculture in the Lower Mississippi River Basin has increased eutrophication and cyanobacteria blooms in freshwater systems in the region. Study lakes, Beasley Lake and Roundaway Lake, are shallow riverine lakes that are differentially impacted by agriculture due to varying implementation of agricultural best-management practices (BMPs). Beasley has approximately 17.1% watershed land-use in BMPs, while Roundaway has only 1.4% watershed land-use in BMPs. From 2017 to 2019, both lakes were monitored for nutrients and cyanobacteria (measured as phycocyanin concentration). During the study years, average annual total nitrogen (TN) ranged from 1.152–1.346 mg/L and 2.046–2.330 mg/L in Beasley and Roundaway, respectively. Average annual total phosphorus (TP) ranged from 0.112–0.169 mg/L and 0.230–0.414 mg/L in Beasley and Roundaway, respectively. Average annual summer cyanobacteria blooms ranged from 31–52 µg phycocyanin/L and 152–197 µg phycocyanin/L in Beasley and Roundaway, respectively. Cyanobacteria nutrient limitation and nutrient sensitivities were assessed to determine nutrients and concentrations eliciting cyanobacteria blooms in both lakes. Results indicate that summer cyanobacteria biomass is primarily nitrogen + phosphorus co-limited in both lakes. However, summer cyanobacteria biomass was lower in Beasley due to more watershed BMPs. Nutrient sensitivities indicated that summer lake cyanobacteria blooms occurred when TN was greater than 0.39 to 0.53 mg/L and TP was greater than 0.055 to 0.066 mg/L. Regression analysis showed that the greater frequency of TP above 0.06 mg/L, the greater cyanobacteria biomass. This study provides evidence of conservation management practices mitigating nutrients and cyanobacteria blooms to improve water quality.

Interactive Session C3: Community Dynamics

November 17, 2021 | 12:00 pm – 1:30 pm EST

*Fish Community Assessment of an Urban Stream, Tahlequah Creek, Tahlequah, Oklahoma

Cale A. Corley, Juliane Perry, Walker John, and Richard M. Zamor
Northeastern State University, Tahlequah, Oklahoma

Rivers and streams are among the most threatened ecosystems worldwide, and their fish assemblages have been modified by anthropogenic habitat alteration and the introduction of non-native species. In the present study we will be assessing the diversity of the current fish assemblage of Tahlequah Creek. We will be comparing our fish assemblage assessment with a historical assessment of the creek's fish assemblage conducted in 1988. This assessment by Jester *et al.* (1988) was made prior to significant water quality infrastructure improvements in Tahlequah, including replacing chlorine water treatment with ultraviolet, the implementation of tertiary treatment and phosphorus removal, and the removal of sewage effluent directly entering the creek at its headwaters. Hence, with these improvements it is possible that fish diversity might also be affected. Additionally, we will be comparing historical water quality data with the present water quality data, to determine how this creek system has changed over the last thirty years. We will survey seven sampling sites on Tahlequah Creek from its headwaters to where it meets the Illinois River. Sites will be sampled monthly via electrofishing and water quality will be assessed for general physical water quality parameters and nutrients.

*Monitoring Freshwater Estuarine Ecological Populations Using a Novel Machine Learning Methodology

Thomas Y. Chen
Academy for Mathematics, Science, and Engineering, Rockaway, New Jersey

Wildlife in estuarine habitats, including crabs, fish, lobsters, clams, raccoons, marine worms, opossums, skunks, and reptiles, are crucial to the biodiversity of Earth. These unique ecosystems teem with a variety of species and assessing populations is key to informing conservation strategies. To better understand estuarine regions and the wildlife that inhabit them, we propose a novel computer vision dataset and deep learning algorithm to classify, identify, and semantically segment animals in imagery. We collect a dataset of acceptable quantity for machine learning purposes by aggregating and scraping Google Images and Flickr with relevant queries. After cleaning the dataset appropriately and crowdsourcing labels, we train a baseline ResNet50 convolutional neural network architecture model on the imagery dataset. For the baseline model, we achieve a 0.79 weighted f1-score on the testing set, which comprises 20% of the dataset. We encourage the computer vision and ecological sciences communities to improve on this baseline in the future. By deploying these technologies in the real world, individual, species, and ecosystem-level wildlife assessment will be greatly improved through automated mechanisms, leading to more targeted conservation efforts.

*Quagga vs. Zebra: Assessing Population Dynamics Between Two Invasive Mussels

Sierra Stickney, Kiyoko Yokota, and Paul H. Lord
State University of New York College at Oneonta, Oneonta, New York

Quagga mussel (*Dreissena bugensis*) and zebra mussel (*Dreissena polymorpha*) are two aquatic invasive species (AIS) that have invaded Otsego Lake in Otsego County, New York, USA. Zebra mussel was first reported in the lake in summer 2007, and its population size appeared to have stabilized over the last decade. Quagga mussel was first detected in August 2020. They pose a threat to Otsego Lake's ecology as they are expected to remove substantial amounts of phytoplankton from the water, reducing food availability for other grazers. If this leads to lower water quality, the local economy and public health can be affected. We deployed ten mussel samplers along a lake shoreline from February to May 2021 to identify and quantify mussels that settle on the blank sampler plates. The vast majority of the settlers were quagga mussels, showing their competitive advantage in cold water under ice. Our results substantiate the concern that quagga mussel, with its cold tolerance and ability to survive and reproduce at deeper depths as reported from other lakes, will begin to outcompete the zebra mussel in Otsego Lake. Changing climate as well as localized anthropogenic thermal alterations, such as those due to dock de-icers (forced circulation or aeration), could potentially affect the dynamics between the two bivalves.

Taxonomic Harmonization of Diatom Counts From Lake Sediment Cores of Northeastern United States

Marina G. Potapova[1], Sarah A. Spaulding[2], and Sylvia S. Lee[3]
[1]Academy of Natural Sciences of Drexel University, Philadelphia, Pennsylvania; [2]USGS/INSTAAR, Boulder, Colorado; [3]US EPA, Washington, District of Columbia

Diatoms are widely used for tracking environmental change and various diatom datasets were employed in the past to evaluate human impacts on lakes of the Northeastern United States. Merging datasets generated at different times by different researchers and laboratories for further large-scale studies has been challenging because of the taxonomic inconsistency caused by rapidly evolving diatom nomenclature and taxonomic concepts. We collated five datasets of lake sediment diatoms from the Northeastern US generated by State and Federal agencies from 1991 to 2018 using the following harmonization process. First, after updating 2172 taxa names used in 1326 lake sediment samples to currently accepted diatom names, we obtained a "nomenclaturally" harmonized dataset. Second, we revised name usage in subsets of data generated by different laboratories by identifying known taxonomic synonyms and inspecting diatom slides and images associated with these data. We also used Indicator Species Analysis to identify names that were inconsistently applied among data subsets and that caused major disagreements among these subsets. Each harmonization step led to a progressive increase of the amount of variation in species data explained by environmental variables and a parallel decrease of the variation attributable to taxonomic inconsistency as estimated by partial constrained ordination analyses. However, the harmonization was achieved at the expense of taxonomic resolution, which is important to preserve for investigations of diatom species distribution patterns and identification of assemblage attributes that can be used as environmental indicators. We, therefore, constructed a dataset of original and harmonized counts, name translation schemes and specimen museum location data to enable further studies of the data and underlying physical specimens. A Voucher Flora set of images representing diatom specimens from Northeastern USA lakes is linked to the harmonized dataset as means of promoting taxonomic consistency of diatom count data generated in future.

Interactive Session C4: Collaborative Management

November 17, 2021 | 12:00 pm – 1:30 pm EST

A Public-Private Approach to Lake and Watershed Management in the Highlands Region of New Jersey

Chris Mikolajczyk, Jesse Smith, and Robert Costello
Princeton Hydro LLC, Ringoes, New Jersey

The Highlands Council is an appointed body tasked with implementation of the New Jersey Highlands Water Protection and Planning Act. The Highlands Council is advised by its Executive Director, who serves as the chief administrative officer. The Council routinely provides grant funding for planning initiative studies within the area. These studies can include land use and development, infrastructure, resource management, and recreation and preservation.

Within the Resource Management approach, specifically, lake Management Planning (identify water quality/quantity issues affecting lakes and develop long- and short-term strategies to protect, restore, and enhance lake aquatic resources to support lake ecosystems, wildlife, and human recreational use), in 2019, the Borough of Ringwood petitioned the Council for public funding to address both lake and watershed management utilizing a regional approach. However, it is important to note that the six (6) lakes in the project are private communities. The Borough was the first in the state of New Jersey to initiate this regional approach through a public-private partnership which will focus on a watershed-based assessment of Ringwood's lakes. The project kicked off in the Fall of 2019 and the baseline and storm water watershed-based assessment occurred through the full growing season of 2020. The results of the assessment sought to address both nonpoint source impacts (Township) as well as any in-lake based sources of impact (Private lake associations). Using Ringwood as a model, the Townships of West Milford (18 lakes) and Rockaway (12 lakes) followed up with their own community projects in the Fall of 2020, respectively.

Collaborative University Research Helps to Ensure Sound Science in Watershed Decision-Making

Robert Nairn[1], Darrell E. Townsend II[2], and Robert C. Knox[1]
[1]Center for Restoration of Ecosystems and Watersheds, University of Oklahoma, Norman, Oklahoma; [2]Grand River Dam Authority, Langley, Oklahoma

Multi-stakeholder partnerships are key to productive and effective watershed management. Active citizen involvement is crucial for long-term success and sustainability, but university research provides unique perspectives and contributions when working in close partnership with lake and watershed managers. The Grand Lake o' the Cherokees watershed provides jurisdictionally complex economic, ecological, and cultural issues and serves as an excellent testbed for execution of applied research collaborative partnerships. The watershed drains portions of four states (Oklahoma, Kansas, Missouri, and Arkansas) and the treaty lands of ten sovereign Native Nations. The predominantly agricultural watershed also includes the historic Tri-State Lead-Zinc Mining District and multiple Superfund Sites. The Grand River Dam Authority (GRDA; a public power utility charged with ecosystems and watershed management) established the Ecosystems and Education Center (EEC), including a state-of-the-art water quality laboratory, in 2009. That same year, GRDA entered the first of two ten-year agreements with the University of Oklahoma (OU) through the Center for Restoration of Ecosystems and Watersheds (CREW) to financially support student research. The laboratory was partially equipped by the university and the EEC provides an in-watershed research base for CREW's long-term biogeochemistry and ecological engineering research efforts. In 12 years, over 20 graduate students, six environmental science and engineering senior capstone classes, multiple internships, and a faculty sabbatical have been supported through this partnership. Research efforts focus on water quality, including nutrient pollution and eutrophication (including harmful algae blooms) and ecotoxic trace metals, and emphasize natural infrastructure solutions to provide multiple ecosystem services and societal benefits.

Utilizing Practitioner-Directed Ecosystem Restoration Projects in Environmental Capstone Classes to Improve Educational Effectiveness and Enhance Community Impacts

Robert C. Knox and Robert W. Nairn
University of Oklahoma, Norman, Oklahoma

Undergraduate students studying Environmental Science or Environmental Engineering at most institutions are required to complete a "Capstone" experience that culminates their degree program. Practitioner-directed capstone classes involve working under the direction of a practicing environmental professional engaged in a "real world" environmentally focused project for some community, civic organization, or environmental authority. The practitioner(s) proposes a specific project with relevant work efforts that will complement their real-world assignments and can be completed by undergraduate environmental science and engineering capstone students. Faculty members work with the practitioner to refine the proposed capstone project to meet the educational objectives of the capstone course. These mutually beneficial relationships result in positive "community engagement" which is an increasingly important factor touted by universities. This presentation will focus on describing the structure, general content, and effectiveness of the two-semester practitioner-directed capstone course sequence used in environmental science and environmental engineering programs in the School of Civil Engineering and Environmental Science (CEES) at the University of Oklahoma (OU). An extensive list of historical projects is presented to demonstrate the variety of governmental entities (clients) that can participate in, and derive positive community impacts from, university-practitioner partnerships. The presentation concludes with a comprehensive listing of the critical aspects for developing and implementing environmentally-oriented capstone courses and a list of the student, university and community/state benefits of using real-world, practitioner-directed experiences for undergraduate environmental engineering and science students for ecological assessment and restoration projects.

Kiamichi River Sustainable Rivers Program

Kimberly Elkin(1) and Tony Clyde(2)
[1]The Nature Conservancy – Oklahoma Chapter, Stonewall, Oklahoma; [2]United States Army Corps of Engineers, Tulsa, Oklahoma

The Kiamichi River is one of Oklahoma's most biologically diverse watersheds. This river is home to 100 fish species and 31 mussel species. Protecting biodiversity is extremely important in a time when biological diversity is declining significantly worldwide. The Sustainable Rivers Program is a collaborative effort between the United States Army Corps of Engineers and The Nature Conservancy. The program has been in existence for almost 20 years now. The program works to find ways to manage river infrastructure to benefit people and nature. Projects are found all over the United States with Oklahoma having its first project starting in 2020 in the Kiamichi River Watershed. Tasks consisted of conducting stakeholder outreach meetings, reviewing the hydrologic period of record and dependable yield analysis, and a literature review culminating in a state of the science report. The Sustainable Rivers Program seeks to find ways of creating operating plans that can incorporate environmental flows. Flow requirements vary across river systems, so analysis of the existing data is crucial to finding alternatives to dam management. A systems wide approach to river management is crucial in order to protect biological diversity as well as maximize the benefits rivers provide for people ad nature.

Interactive Session D1: Public Policy & Education

November 17, 2021 | 2:00 pm – 3:30 pm EST

Stormwater Education and Outreach in the Flathead Basin

Emilie Henry[1] and Casey Lewis[2]
[1]Big Sky Watershed Corps (AmeriCorps), Kalispell, Montana; [2]City of Kalispell, Kalispell, Montana

As development in northwest Montana rapidly expands, the quality of the Flathead Basin's pristine waters is expected to face increasing threats, in part due to a rise in stormwater pollution. To preempt these emerging threats, the City of Kalispell, Flathead Conservation District, and Flathead Basin Commission have partnered to create two education and outreach initiatives – the Flathead Rain Garden Initiative and an Adopt-a-Drain campaign in Kalispell, Montana. The goals of these initiatives are to educate residents about stormwater pollution and provide opportunities to help with mitigation. Launched in 2020, the Flathead Rain Garden Initiative provides landowners in Flathead County with the knowledge, resources, and support to build rain gardens on their property. To do this, the initiative hosts workshops, conducts site visits, and provides financial assistance through a grant-funded homeowner incentive program. In its first year alone, the program engaged over 41 residents and built 8 rain gardens that manage an estimated 100,000 gallons of runoff annually. The Adopt-a-Drain campaign recruits Kalispell residents to volunteer to regularly remove debris from the surfaces of storm drains near their homes. Initiated in 2021, this burgeoning program hosts volunteer trainings and provides them with the tools to safely and effectively reduce flooding and stormwater pollution. These two programs rely heavily on collaboration, both for effectively leveraging funds and extending outreach beyond the scope of any one organization. Future work will involve expanding these programs to other cities and counties in the basin in order to comprehensively address stormwater in the Flathead Basin.

Clean Water Act 303(d) Program Vision 2.0

Jeff Berckes[1] and Jasper Hobbs[2]
[1]Iowa DNR and ACWA Watersheds Co-Chair, Des Moines, Iowa; [2]Association of Clean Water Administrators, Washington, District of Columbia

Starting in 2011, States and EPA collaborated to develop a new approach to manage the work of the Clean Water Act 303(d) Program, culminating in the development of a ten-year "Vision." For many States, the Vision represented a renewed approach to an existing program that provided additional flexibilities and opportunities including the ability to focus on state-specific water quality priorities. States largely embraced this new approach and integrated it into the daily operation of their program. Additionally, the improved collaboration with EPA benefited Programs at both the state and federal level. States strongly support continued implementation of the Vision and will enter a new Vision period starting in 2022.

The Association of Clean Water Administrators (ACWA) worked with EPA, States, as well as the Environmental Law Institute and NEIWPCC, to collect lessons learned and make recommendations for moving forward beyond 2022. As 303(d) Programs enter a new Vision period, renewed opportunities arise for setting program priorities. NALMS members will learn the state government perspective on what the 303(d) Program Vision is, what programs consider when setting priorities, and what to expect in the near future. Topics of discussion will include potential prioritization considerations such as waterbody usage, recovery potential, economic impact, climate change, and environmental justice issues. Further, the 303(d) Program would benefit hearing how state government programs can communicate program information effectively, better understand the priorities of the public, and deliver useful end products.

The Secret Life of Samples – A Bloom's Eye View

Hunter Nelson and Erin Vorderlandwehr
Oklahoma Department of Environmental Quality, Oklahoma City, Oklahoma

Did you ever wonder what it's like to see things from a different perspective? Most people think of laboratory analysis as a black box where samples go in, and results come out. But there is much more to the process. Staff and scientists, instruments and equipment, preparation and analysis, storage, and disposal and even more. The time and effort and technical aspects involved may explain why it can take variable amounts of time for results to be reported for different tests. This video presentation will give you a new point of view from the sample's perspective. From sample collection to sample disposal and everything in between. We will experience the entire workflow of a hazardous algal bloom sample in the laboratory environment in the hope of shedding some light into an otherwise mysterious process that few, other than laboratory scientists, know much about.

Integrating Healthy Lakes Protection in Watershed-Based Planning

Steve Epting[1] and Sequoya Bua-Iam[2]
[1]US Environmental Protection Agency, Washington, District of Columbia; [2]ORISE Fellow, US Environmental Protection Agency, Washington, District of Columbia

For over twenty years, the EPA's National Nonpoint Source (NPS) Program has promoted the watershed approach as a coordinating framework for designing and implementing comprehensive, watershed-based efforts to protect and restore water quality. The watershed planning process works within this framework by using a series of cooperative, iterative steps to characterize existing conditions, identify and prioritize problems, define goals, develop management strategies, and implement and adapt actions. To date, watershed plans have primarily guided strategies for improving degraded water quality with the goal of attaining water quality standards. However, watershed plans can also provide opportunities to outline strategies to protect unimpaired waters, such as high-quality lakes and ponds.

We will share findings from a review of lake-focused watershed protection plans from Michigan, Maine, New Hampshire, Oklahoma, and Arkansas. This review was part of a recent EPA-led effort to identify current approaches and opportunities to better integrate healthy waters protection in the National NPS Program. Reviewed watershed plans were either developed for an unimpaired watershed, or the plan was developed for a partially impaired watershed and featured an explicit goal to protect unimpaired waters. Based on our review, we will share how watershed plans can be developed to support lake protection efforts by (1) evaluating watershed threats through build-out analyses and water quality modeling, (2) identifying protection priority areas (*e.g.*, high priority parcels for land conservation), (3) outlining protective lake management strategies (*e.g.*, phosphorous reduction ordinances), and (4) developing protection-based measures of success for both nutrient targets and social factors.

Interactive Session D2: HABs – Case Studies 2

November 17, 2021 | 2:00 pm – 3:30 pm EST

*Monitoring of Variable Cyanobacterial Harmful Algal Blooms in Lake Fayetteville, Arkansas

Alyssa Ferri, Brian E. Haggard, and Brad J. Austin
Arkansas Water Resources Center, Fayetteville, Arkansas

Worldwide, anthropogenic eutrophication damages freshwater ecosystems and leads to the proliferation of cyanobacterial harmful algal blooms (CyanoHAB) (Carmichael 2001). CyanoHABs negatively affect freshwaters through the production of toxins and often subsequent hypoxia from the decay of the biomass. CyanoHABs are a concern regionally and locally in lakes and reservoirs regarding recreational contact and water supply. Lake Fayetteville has been experiencing CyanoHABs for many years, and we have been monitoring this occurrence on a near weekly basis since 2019. The main objective of this study is to understand what triggers toxin (*i.e.*, microcystin) production during blooms. Water samples were analyzed for dissolved and total nutrients, chlorophyll *a* and total microcystin and in the field for pH, dissolved oxygen, and conductivity. In the first year, toxin production started when nitrate supply was being replenished in the epilimnion. For the second year, toxin production occurred after nitrate was depleted (0.1 mg/L) in the waterbody. Further research regarding the onset of microcystin production will be important to mitigate potential negative impacts on human health and the environment.

Algal Growth in Lake George, New York as an Indicator of Water Quality Impacts From Land Use – Analysis From 2020 and Initial Results From 2021

Bregieta Arvidson[1] and Chris Navitsky[2]
[1]Lake George Association, Lake George, New York; [2]Lake George Waterkeeper, Lake George, New York

Harmful Algal Blooms (HABs) pose a worsening threat to water resources and communities in the Lake George basin. 2020 marked the first official HAB documented in Lake George, however algal bloom complaints and observations have been increasing throughout recent years. Understanding that land use impacts water chemistry and periphytic algae are a higher-sensitivity organism than higher order biota (*e.g.*, macroinvertebrates), we can use periphytic algae an effective tool that can indicate natural and anthropogenic changes that may not be detected by chemical monitoring alone.

This study uses collection, analysis, and field observation of periphyton biomass, algal community composition, and periphytic diatom identification to provide insights into the influence of groundwater and land use on the near-shore water quality of Lake George. After a 4-week period, periphyton samples were collected in July and September 2020 and 2021 from clay tiles stationed at 1 m in Cook Bay and Oneida Bay, and 1 m and 4 m in Dunham's Bay in Lake George. Additional 1 m sites in Huddle Bay and the Narrows were included in 2021 for additional site diversity in the study. The preserved samples were analyzed using USGS NAWQA protocol and diatom community metrics were calculated.

From analysis of the initial season results, we establish a composition baseline for each bay that can be used to determine seasonal changes, change at deeper sites, annual trends, and comparison between the bays.

Preliminary Study of HABs in Lake Chautauqua, New York Provides Guidance for Future Research

Vincent W. Moriarty[1], Michael R. Kelly[1], Guillaume A.R. Auger[1], Joel W. Harrison[2], Rick A. Relyea[2], and Harry R. Kolar[1]
[1]IBM Research, Yorktown, New York; [2]Rensselaer Polytechnic Institute, Troy, New York

The term "harmful algal bloom" (HAB) encompasses a wide range of complex ecological phenomena that can manifest in diverse ways; from large-scale regime shifts to ephemeral surface phenomena. The often-dynamic nature of these events can be difficult to characterize using traditional sensor technology, and single or sparsely distributed individual sensors rarely capture the spatial or temporal resolution required to study these events. The Jefferson Project approach, first applied on Lake George, New York, uses a combination of high-frequency real-time sensor data, traditional physical sampling methodology, and hydrodynamic modeling to investigate a variety of lake-specific issues. This approach is now being used to investigate HAB dynamics in other lakes, including Lake Chautauqua, New York. Decisions guiding lake management require knowledge not only of real-time HAB incidents, but of the underlying mechanics driving individual lake systems. By combining three different data streams (sensor data, physical sampling, modeling) the Jefferson Project is endeavoring to not only monitor HAB dynamics at unprecedented resolution, but also to explore and understand the potential drivers of HABs.

Interactive Session D3: Voice of Experience

November 17, 2021 | 2:00 pm – 3:30 pm EST

Critical Lake Management Lessons That I Didn't Learn in School

Jeff Schloss
University of New Hampshire, retired, Durham, New Hampshire

My career trajectory has taken me from researching the marine physiological ecology of fouling organisms and shellfish in North Carolina (for the EPA), understanding phytoplankton and zooplankton dynamics in the Potomac River (for USGS and EPA), modeling and predicting nutrient loads and water quality in multibasin lakes in the Northeast (USGS/WRRC and as a private consultant), to finally, serving as a department chair for Extension faculty in Natural Resources while still keeping my fingers wet collaborating on trying to better understand cyanophyta blooms in New Hampshire lakes.

In the last 35 or so years, I have been privileged to serve as an Extension Specialist and Professor of Water Quality at the University of New Hampshire and Co-director of an internationally recognized volunteer water monitoring program (NH Lakes Lay Monitoring). While the position has allowed me to do research, college teaching and student mentoring, the most challenging aspect has been the development of impactful outreach programs focused on the stewardship of our relatively pristine water resources.

Through my work experience I have come to realize that:

- Volunteer monitors are so much more than just sample takers.
- We need to approach lake stewardship education as a seasoned salesperson would.
- Mark Twain isn't the only social scientist we need to respect.

In my presentation I will further explain these lessons learned and provide examples on how they helped produce successful outcomes.

A Government Career – How and Why It Worked for Me

Mike Bira
US Environmental Protection Agency, retired, Dallas, Texas

My professional career included five years as a state employee in Texas, and 33 years at the USEPA Region 6 office in Dallas, Texas. It was a very rewarding, enjoyable learning process, and I feel blessed to have been able to experience government service. Hopefully I was effective in expending taxpayer money and supporting development of good science and policy to protect and restore water resources. This presentation will generally address what I believe to be the advantages and disadvantages of public service, and what it takes to find fulfillment in that role. It is definitely not for everybody! My experiences and involvement with NALMS are highlights of my career, and I cherish the memories of Clean Lakes Program projects, and all the many wonderful people I have met and gotten to know through NALMS.

Voice of Experience - 50 years of Staying Afloat

Kent Thornton
FTN Associates, Ltd., Little Rock, Arkansas

I've been fortunate to have worked in a university setting (Bowling Green University), in the federal government (US Army Waterways Experiment Station), and in the private sector (FTN Associates) over the past 50 years. I was one of the founding members of NALMS in 1980. Water has been the unifying thread through all of these experiences, obviously including watershed and reservoir management (Our slogan at FTN is "We know H_2O"). I've been blessed to work on water projects in 49 states (still trying for Hawaii); 4 other countries; local, state, and federal agencies; nonprofit organizations, universities, other consulting firms; and numerous industrial clients. Three lessons on watershed and lake management have emerged from these 50 years of experience.

First, broaden your perspective. You are here because of what you know; your future will be dictated by what you learn. Second, Stephen Covey had it right – "Seek first to understand, then to be understood." Third, watershed management is a wicked problem; you won't solve it, but you can resolve it. Each of these lessons will be expanded during the session.

Interactive Session D4: Soil Health

November 17, 2021 | 2:00 pm – 3:30 pm EST

Protecting Resources for Future Generations by Thinking Outside the Box and Inside the Soil

Russ Jackson
Farmer and Rancher, Mountain View, Oklahoma

Third generation rancher from southwestern Oklahoma, Russ Jackson has been on a journey to protect the ranch he inherited for his children and grandchildren near the foothills of one of the oldest mountain ranges on earth. In an arid region with increasingly scarce resources, he began the switch to regenerative agriculture more than a decade ago by converting his cropland to a no-till system and not looking back. Winner of the 2018 Oklahoma Leopold Conservation Award from the Sand County Foundation, Russ has tested many different approaches on his operation to site and regional as well as economic challenges. He partnered with (and encouraged) the Natural Resources Conservation Service, the Noble Research Institute and Soil Health Institute, among others to design and test innovative management strategies that address building soil health. Russ and his partners have measured and demonstrated increased infiltration, increased soil organic matter, and a more diversified, reliable economic outcome from his ranching operation.

Time Traveling Through Regenerative Agriculture in Western Oklahoma: How a Farmer Turned Back Time

Jimmy Emmons
Oklahoma Conservation Commission, Oklahoma City, Oklahoma

Since settlement and cultivation of Oklahoma's native tall and short grass prairie soils, we've lost between fifty to eighty percent of the original soil organic matter and now average between one and three percent in our soils. Oklahoma cropland loses an estimated 36 million tons of topsoil each year, and that is a dramatic improvement from the 64 million tons in the early 1980s. We've been told that it takes between 100 – 500 years to replace an inch of this fertile resource the world relies on for food and fiber. Soil is being swept and washed away 10 – 40 times faster than we are replenishing it; we are quickly approaching the time where the process of rebuilding fertile soils where growing conditions are supported will require, although not geologic time, perhaps more lifetimes than we have in reserve. But what if that isn't the case? What if, in less than a decade, your soil could change from a heavily degraded cropland soil most closely resembling the rock it was weathered from to a grassland soil, comparatively high in organic matter and nutrient enrichment? Was it time travel? Or was it regenerative agriculture?

New Frontiers in Data Collection: A Rapid Assessment Method for Measuring Soil Health Deployed to Track Soil Health Across Oklahoma and Beyond

Amy Seiger
Oklahoma Conservation Commission, Oklahoma City, Oklahoma

Although Soil Science is not a new discipline, much of the way we've communicated and studied it has been based primarily around its physical properties. As anthropogenic influences accelerated soil loss and depletion of soil quality, we've studied and developed methods to artificially replace micro and macronutrient content and improved access to supplemental irrigation. Although work is being done to better understand the role of microorganisms in soil and their relationship to conservation, farmers are pushing forward with progress based on what they see and hear as opposed to what can be measured. And as farmers continue to look for alternative solutions to problems such as lower fertility and increasing input costs, and in doing so, push researchers to support them, we've discovered a need to measure the biological (and related) properties of soil. And since Farmers learn best from other Farmers, we need methodologies and tools that can be deployed by farmers. The USDA Natural Resources Conservation Service developed a yardstick to measure soil health and the Oklahoma Conservation Commission and partners have adapted the tool to a mobile application that can be deployed statewide (or beyond) with limited training and even more limited tools. Working on Regenerative Management Systems (WORMS) is a tool that is tunneling through the ground between academicians and practitioners to evaluate progress in soil health.

The Conservation and Agriculture Reach Everyone Project (CARE): Improving Natural Resources Conservation in Oklahoma Through Collaboration With Veteran and Socially Disadvantaged Farmers and Rancher

Sarah Blaney
Oklahoma Association of Conservation Districts, Oklahoma City, Oklahoma

The Conservation and Agriculture Reach Everyone (CARE) Project is a collaborative effort led by the Oklahoma Association of Conservation Districts (OACD) with the Oklahoma Black Historical Research Project, Texas Agriforestry Small Farmers & Ranchers, and Association of Texas Soil & Water Conservation Districts. The purpose is to increase the number of farmers/ranchers participating in conservation planning and programs in order to improve soil health, water quality, and the viability of working lands. The CARE project places an emphasis on assisting historically underserved and veteran farmers/ranchers. Although its beginning was delayed by the COVID pandemic, the program is beginning to examine barriers to participation and access for these communities, design conservation practices to address issues, and is offering a collaboration of assistance programs to get those practices installed. Along the way, the program is measuring environmental conditions related to soil health before and after installation of conservation practices and providing training opportunities to encourage more members of these communities to become active participants and leaders in the conservation community. Results of the project will include nearly 30 veteran, historically underserved or socially disadvantaged demonstration farms and agricultural producers who will have successfully navigated the application and conservation planning process and who can help guide other members of their community toward similar results. These CARE Champions will also attend leadership and conservation training courses and meetings to encourage their growth as future conservation leaders.

Interactive Session E1: Water Quality Monitoring

November 17, 2021 | 4:00 pm – 5:30 pm EST

Around Arkansas in 180 days, 13 Watershed Assessments for NRCS

Jeremy Rice[1] and Amanda Mathis[2]
[1]Freese and Nichols, Tulsa, Oklahoma; [2]NRCS – Arkansas, Little Rock, Arkansas

The consultant team completed 13 watershed assessments (43 HUC 12s, over 1 million acres) in Arkansas for the Mississippi River Basin Healthy Watersheds Initiative (MRBI) and the National Water Quality Initiative (NWQI) to improve water quality, reduce sedimentation, improve wildlife habitat, and promote sustainable stewardship of soil and water resources.

The assessments included physical and hydrologic watershed characterization, resources analysis and source assessment and summary and recommendations. The project also included spreadsheet water quality modeling (STEPL) for each watershed along with detailed geographic information system (GIS) data and analyses. Each assessment includes a description of the water quality impairments and information showing areas that may benefit from implementation of Best Management Practices (BMPs) and/or other management measures.

The watershed assessments provide the NRCS Arkansas with actionable data to prioritize the implementation of targeted watershed scale projects which encourage agriculture producers to adopt on-farm conservation practices by providing financial assistance to offset the cost of implementation. NRCS staff are utilizing these assessments to hold meetings with stakeholders and producers to identify the critical conservation practices and established treatment goals for the projects. These assessments may result in $8 million or more of targeted financial assistance to address resource concerns in Arkansas.

*Manually Collected Data From Lake Water Quality Sampling Programmes May Contain Significant Weather Biases

James Rand[1], Mirjam Nanko[2], Mikkel Lykkegaard[2], Danielle Wain[3], Lee Bryant[1], and Alan Hunter[1]
[1]University of Bath, Bath, Bath and North East Somerset, UK; [2]University of Exeter, Exeter, Devon, UK; [3]Colby College/7 Lake Alliance, Waterville, Maine

Regular sampling is a common component in the design of most manual lake water quality monitoring programmes and is done to measure water quality through the season. However, it is believed that the influence of weather on lake monitoring, and especially when involving boat handling in wind and rain, must disrupt such intended regular sampling. Whilst such weather-influenced sampling biases are instinctively acknowledged by lake scientists and have been observed anecdotally, they are not substantially addressed in the literature. Here, we demonstrate a statistically significant weather bias effect on manual lake measurements and show this in a real-world case study.

Our hypothesis is that manual water quality sampling is subject to bias due to weather conditions and that this bias causes a discernible impact upon the characterisation of manually obtained water quality parameters. In the case study, manually collected water temperatures are, on average and depending upon the statistical analysis used, between 0.5 °C and 1.0 °C higher than those collected using automated methods.

The methodology used to obtain these results may be applicable to (a) other water quality parameters and (b) to similar manually sampled lake monitoring programmes, though further analysis is needed to confirm this. However, if these findings are generally applicable, they represent a significant and unaccounted-for error when using manually collected lake water quality data in such areas as modelling and climate change studies.

Volunteer-Collected Water Quality Data Can Be Used for Science and Management

Mark Hoyer
Florida LAKEWATCH, University of Florida, Gainesville, Florida

This study addresses concerns that comparison studies between professional and volunteer-collected data have been of limited scope, conducted under experimental conditions, and that results may not be applicable to existing large-scale, long-term volunteer monitoring datasets. Historical (2008 to 2019) phosphorus, nitrogen, chlorophyll, and Secchi data collected by five Florida organizations charged with monitoring water quality were compared with Florida LAKEWATCH volunteer-collected data from 216 lakes. The state organizations had National Environmental Laboratory Accreditation Conference (NELAC) certified laboratories and LAKEWATCH used modified procedures needed to accommodate a volunteer program. The lakes are located in central Florida, range in trophic status from oligotrophic to hypereutrophic and provided approximately 650 independent overlapping annual geometric mean pairs for comparison. Paired t-tests comparing logarithmic transformed annual geometric mean data pooled from all professional organizations with similar overlapping volunteer-collected data showed significant ($P < 0.05$) differences for phosphorus, nitrogen, and Secchi depth but not chlorophyll. The significant differences when reported arithmetically were only 1.1 µg/L, -1.1 µg/L, and 0.1 m, respectively. Regression analyses on the same data showed strong significant ($P < 0.05$) relations with coefficient of determinations (R^2) of 0.91, 0.98, 0.79 and 0.78 for phosphorus, nitrogen, chlorophyll, and Secchi depth, respectively. Slopes for each paired regression were not significantly different from one. These results demonstrate that volunteer-collected data were equivalent to data collected professionally, that the quality of volunteer data can be similar to that produced by NELAC certified laboratories, and thus that data are adequate for both research and management.

*The Value of Volunteers: 32 Years of Citizen Science Monitoring in Indiana

Lindsey Rasnake
Indiana University, Bloomington, Indiana

The Indiana Clean Lakes Program (INCLP) volunteer lake monitoring initiative, run out of the Limnology Lab at the Indiana University O'Neill School of Public and Environmental Affairs, provides essential water quality data on lakes throughout the state. Currently, more than 80 citizen scientists monitor 200 lakes across Indiana, collecting Secchi disk measurements as well as temperature/dissolved oxygen profiles, and monitoring aquatic invasive species. Each summer expanded monitors collect water samples for analysis of total nitrogen (TN), total phosphorus (TP), and chlorophyll *a*, contributing to an ongoing dataset that allows us to view trends in lake water quality over time. More than 70 of the lakes in the monitoring program are private, and volunteers on these lakes help fill a data gap for water quality throughout the state. As concerns about nutrient pollution and harmful algal blooms rise in Indiana, this monitoring program plays an important role in illustrating water quality conditions and making management decisions. We examine the expansion of the monitoring program over the last 32 years and discuss the value of citizen science data and partnership as well as our vision for continued improvement of the INCLP volunteer lake monitoring program.

Interactive Session E2: HABs – Potential Causes

November 17, 2021 | 4:00 pm – 5:30 pm EST

Are Stormwater Ponds Incubators for Harmful Algal Blooms?

Tyler Olsen[1], Katie Turpin-Nagel[1], Josh Maxwell[2], and Joe Bischoff[1]
[1]Barr Engineering Co., Minneapolis, Minnesota; [2]Riley Purgatory Bluff Creek Watershed District, Chanhassen, Minnesota

Stormwater ponds are one of the most common practices in Minnesota used to reduce pollutant loading by settling and storing sediment and nutrients in watershed runoff. Many of these ponds are in well protected areas of the watershed resulting in calm, warm, and high nutrient water creating ideal conditions for harmful cyanobacterial algal blooms. Many of these stormwater ponds are viewed as assets to surrounding residents with intensively used shoreline areas including patios close to the pond and sometimes docks. While residents may not come in direct contact with pond water, pets are certainly at risk. More concerning are recent studies that suggest cyanobacteria may represent a threat to public health through aerosolization. Because current stormwater pond design standards focus on modeling sediment and phosphorus settling and not on measured pond water quality, the Riley Purgatory Bluff Creek Watershed District (RPBCWD) monitored water quality in 9 stormwater ponds. Conditions in all 9 of the ponds were ideal for cyanobacteria blooms with high nutrients, warm temperatures, and low dissolved oxygen that can lead to sediment phosphorus release. Measured phycocyanin, a photosynthetic pigment specific to cyanobacteria, was high in many of the ponds suggesting that harmful algal blooms were occurring. Other monitored ponds were dominated by duckweed on the pond surface, likely limiting light availability for cyanobacteria production. This presentation will discuss the factors that make stormwater ponds vulnerable to harmful algal blooms and considerations for stormwater managers to prevent public health risks from harmful algal blooms in stormwater ponds.

Factors Contributing to High Interannual Variation in the Onset of Anoxia and Concomitant Internal Loading of Phosphorus That Influence Harmful Algae Blooms

Frank M. Wilhelm, Sarah H. Burnet, and Brianna Frazee
Department of Fish and Wildlife Sciences, College of Natural Resources, University of Idaho, Moscow, Idaho

The availability of excess nutrients in lakes and reservoir stimulates primary productivity that results in algae blooms, some of which can produce potent toxins. In the US west, where inflow contributions from the watershed are greatly reduced after snowmelt, internal loading of nutrients, especially P, can be a large proportion of the annual nutrient budget. As part of regular monitoring over the last 10 years, we recorded a large interannual variation (up to 8 weeks) in the onset of anoxia in the hypolimnion of Willow Creek Reservoir, Oregon. Given that P concentrations in the hypolimnion can reach 600–800 μg/L, the timing of the onset of anoxia plays a large role in the vertical distribution of this internally loaded P, and thus its availability via entrainment and diffusion to surface waters. We examined factors such as spring runoff volumes, reservoir elevation (volume) in spring, rate of water column warming in spring and stratification intensity, wind mixing, and the primary productivity in the previous year to help explain this variation in aerial hypolimnetic oxygen depletion. Our goal is to build a predictive relationship that will allow managers to proactively manage an aeration system to reduce internal loading of P and productivity in surface waters.

Low Sediment Redox Promotes Cyanobacteria Blooms: Implications for Bloom Management

Lewis A. Molot[1], David C. Depew[2], Arthur Zastepa[2], Sherry L. Schiff[3], Jason J. Venkiteswaran[4], Helen M. Baulch[5], Scott N. Higgins[6], Mark J. Verschoor[7], and Daniel Walters[8]
[1]Faculty of Environmental & Urban Change, York University, Toronto, Ontario, Canada; [2]Environment and Climate Change Canada, Canada Centre for Inland Waters, Burlington, Ontario, Canada; [3]Department of Earth and Environmental Sciences, University of Waterloo, Waterloo, Ontario, Canada; [4]Department of Geography and Environmental Studies, Wilfrid Laurier University, Waterloo, Ontario, Canada; [5]School of Environment and Sustainability, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; [6]International Institute for Sustainable Development-Experimental Lakes Area, Winnipeg, Manitoba, Canada; [7]Department of Biology, York University, Toronto, Ontario, Canada; [8]Department of Geography, Nipissing University, North Bay, Ontario, Canada

Evidence shows that low sediment redox caused by depletion of O_2 and nitrate allows cyanobacteria blooms to form while oxidation of anoxic sediments by high nitrate or O_2 prevents blooms in eutrophic freshwaters. This explains why the risk of bloom formation, *i.e.*, displacement of eukaryotic algae by cyanobacteria, increases with increasing phosphorus: higher productivity increases the risk of anoxia and nitrate depletion which causes low sediment redox. Long term and seasonal nitrate trends account for the absence of blooms in highly eutrophic Hamilton Harbour (Lake Ontario) in the 1970s when nitrate was high and, following a decline in nitrate in the 1980s, the appearance of late summer blooms. The nitrate threshold for bloom prevention in Hamilton Harbour is similar to thresholds observed elsewhere. While anoxic sediments are common in summer and fall in eutrophic waters, differences in nitrate might help explain why blooms form at different times. The concept of 'low sediment redox as bloom promoter' has major potential to improve bloom management if managers consider the impact of their watershed and in-lake management methods on sediment redox. Phosphorus input targets can be adjusted to maintain oxidized sediments as climate change alters the extent of anoxia; short-term bloom prediction models incorporating the sediment redox concept could predict bloom onset up to 2 weeks earlier than current models which depend on detecting increased cyanobacteria pigments during the early stages of bloom formation. Evidence suggests that removing nitrate can exacerbate blooms and allow earlier development.

*Nutrient Addition Affects Harmful Algal Bloom Biomass and Cyanotoxin Production

Lillie Haddock[1,2], Brian E. Haggard[1,2], Bradley J. Austin[1], Alyssa Ferri[1,3], Nicole D. Wagner[4], and Thad Scott[4,5]
[1]Arkansas Water Resources Center, University of Arkansas, Fayetteville, Arkansas; [2]Biological and Agricultural Engineering Department, University of Arkansas, Fayetteville, Arkansas; [3]Crop, Soil, and Environmental Sciences Department, University of Arkansas, Fayetteville, Arkansas; [4]Center for Reservoir and Aquatic Systems Research, Baylor University, Waco, Texas; [5]Department of Biology, Baylor University, Waco, Texas

Harmful Algal Blooms (HABs) are becoming a global concern due to their increasing distribution, frequency, intensity, and the occurrence of toxins. While it is known that eutrophication influences algal blooms, there is less known about what triggers these HABs to produce toxins, especially microcystin. In this study, we will conduct 10 community bioassays from April–November 2021 to examine how the addition of phosphorous and nitrogen influence algal biomass, stoichiometry, and microcystin production. These experiments will include a control, nitrogen (1.0 mg/L as KNO_3), low phosphorus (0.025 mg/L as K_2HPO_4), high phosphorus (0.100 mg/L) and nitrogen plus low and high phosphorus treatments with four replicates, where the treatments will be incubated in a chamber at temperature representing lake conditions below the surface and a light intensity of 140 µmol/L with 14 hours light and 10 dark. The historic lake water quality shows that nitrate supply diminishes in May, then nitrate is less than 0.1 mg/L throughout the rest of the growing season. On the other hand, dissolved phosphorus supply is low throughout the growing season. These bioassays will take place throughout the nitrate decline and well into the growing season when dissolved nutrients are not readily available in the surface water.

Interactive Session E3: Alum 1

November 17, 2021 | 4:00 pm – 5:30 pm EST

Geochemical Augmentation With Alumina for Phosphorus Attenuation in Lake and Reservoirs – Summary of Project Results in Five Basins

David Austin and Roger Scharf
Jacobs, Saint Paul, Minnesota

Geochemical augmentation is a method to enrich basin water with hydrous aluminum oxide (HAO) complexes in solution or in colloidal suspension to scavenge phosphate from water and sequester it in sediments. Dosing protocols maintain total aluminum concentrations below the US EPA ambient aquatic aluminum criteria chronic toxicity threshold (criterion continuous concentration – CCC) as calculated for the basin from pH, dissolved organic carbon, and total hardness inputs to the EPA model. Project data (2015–2021) include a stormwater-fed urban lake, one river reservoir, and three reuse reservoirs. In all projects, alum or aluminum chlorohydrate was injected into an air or pure oxygen bubble plume at the bottom each basin. Results for all basins are similar. Addition of alumina lowered TP to the 10 to 60 µg/L range from initial concentrations as high as 250 µg/L at a rate near 1 µg/L/day. Concentrations of total Al were measured in four of five projects reported herein remained a small fraction of CCC despite continual dosing. Geochemical modeling by Sumo© appears to capture the dynamics of TP removal using methods developed for hydrous ferric oxide (HFO) complexes. Convergent results from five full-scale projects, low cost, and operational flexibility of geochemical augmentation merits communication to the wider community of lake managers and limnologists as an emerging method to control eutrophication.

Effectiveness of Alum in an Urban Kettle Lake With a Long History of Toxic Blooms

Shannon Brattebo[1], Harry Gibbons[2], Iris Lippert[2], and Paul A. Bucich[3]
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Waughop Lake is a glacial kettle lake (33 acres) located in Lakewood, Washington, approximately 42 miles south of Seattle, and is the centerpiece of the popular Fort Steilacoom Park. The lake has no natural surface water inflows or outflows but is in contact with shallow groundwater. Waughop Lake has a long history of toxic cyanobacteria blooms and health advisories during the past decade. The City of Lakewood made the restoration of Waughop Lake a high priority and treated the lake with alum to reduce internal phosphorus (P) loading by inactivating sediment P and subsequently reduce blooms. The total aluminum (Al) dose for Waughop Lake was determined based on mobile sediment P which was relatively high due to animal food processing waste and manure discharged into the lake over 50 years ago. Sediment conditions within the top 50 cm required that the dose (120 mg Al/L) be applied to the lake in three separate applications at a dose of 40 mg Al/L, over the course of two years. The first application occurred in March 2020 and the second in July 2020. The third application was postponed and will be reevaluated based on continued water quality monitoring in 2021. Overall, the alum treatments reduced lake TP by 83% from March 2020 to March 2021 and reduced chlorophyll by 91%. Water clarity dramatically increased following treatment and remained at the bottom of the lake throughout spring 2021. Post treatment results through March 2021 and from summer volunteer monitoring will be presented.

A Multi-Year Alum Treatment Success Story in Central Minnesota

Erik Bye[1] and Dick Osgood[2]
[1]SEH, St. Paul, Minnesota; [2]Lake Advocates, St. Paul, Minnesota

The purpose of this project was to reduce nuisance algae, nutrient levels and increase aesthetic qualities of Lake George, in St. Cloud, Minnesota. This was achieved through a comprehensive approach combining in-lake alum treatments and watershed stormwater BMPs. A unique aspect of this project was alum dosing was applied for three consecutive summers to reduce internal phosphorus loading and continue stripping phosphorus from the water column until the stormwater BMP was constructed this summer to treat runoff entering the lake. The newly constructed underground stormwater BMP is now expected to remove excess nutrients from runoff and lower the overall surface runoff into the lake by infiltrating stormwater.

The alum treatment has proven successful thus far – reducing overall nutrient levels and producing positive trends in the lake's water quality indicators. The total phosphorus and chlorophyll *a* levels have been reduced by almost 50% and maintained compared to pre-treatment levels. Secchi depth measurements have increased by nearly 40%. Fisheries habitat has improved as well, demonstrated by multiple rainbow trout (stocked in 2017 and 2019) being caught. Data from this summer will be collected and analyzed to determine changes in water quality following construction of the stormwater BMP this Spring. As a result of the success of this project, the lake will also likely be removed from the EPA 303(d) list this year.

Bioretention for Lakes: Washington's Search to Replace Compost in Our Stormwater Filters

Dylan Ahearn[1], Douglas Howie[2], and Jenee Colton[3]
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Bioretention is the most widely applicable and flexible stormwater treatment practice we have available today. The Washington State Department of Ecology (Ecology) specification for bioretention soil media (BSM) is a mixture of 60 percent sand and 40 percent compost (60/40). Washington is not alone by including compost in BSM; Massachusetts, Nebraska, Maryland, Colorado, the list goes on. While the 60/40 BSM can provide reliable water quality treatment for some contaminants, it has been shown to export high levels of nitrogen and phosphorus.

We will present the journey that the state of Washington has taken over the last 6 years to find an alternative to compost in BSM. From selecting and testing individual components in the lab, to column studies, toxicological studies, and plant health assays, we developed a new BSM that is an effective nutrient filter. The final mix, High Performance BSM (HPBSM) is a combination of sand, coconut coir, biochar, iron filings, and activated alumina. We have documented median removals of 73 and 5 percent for total phosphorus and nitrate+nitrite, respectively. This contrasts with order of magnitude increases in these constituents using the 60/40 BSM. The HPBSM also reduces stormwater toxicity and can sustain a healthy plant community.

Ecology recently released the HPBSM specification for use in Washington. Bioretention, once prohibited from being installed adjacent to sensitive lakes, can now be used across the state, expanding the reach of this powerful stormwater treatment tool, and protecting our lakes and streams.

Interactive Session E4: Conservation & Management

November 17, 2021 | 4:00 pm – 5:30 pm EST

Promoting Loss for Gains in Implementing Conservation Practices

Kent Thornton
FTN Associates, Little Rock, Arkansas

Nonpoint source pollution results in significant loss of value and worth for the use of aquatic resources each year in the US. Agricultural land use is not only one of the major contributors to nonpoint source pollution, it is also a major contributor to the economy of nearly every State in the Great Plains and Mississippi River Basin. In large, agricultural nonpoint sources are addressed through the voluntary implementation of management practices. How, then, do you entice agricultural producers to voluntarily implement best management practices without impacting their profit margin and their contributions to the economy? Behavioral economics tells us that one of the greatest motivators for nearly everyone is fear or risk of loss. In developing and implementing watershed management plans, therefore, we have emphasized landowner losses, rather than the benefits, from not implementing BMPs. We have focused on motivational and ability-enhancing activities to over-determine success (Grenny *et al*. 2013). Motivating someone to change their behavior only leads to frustration if they don't also have the ability to change. Three subdomains are invoked within each of the motivation and ability domains: personal, social, and structural. Cover crops are a practice that permit us to simultaneously emphasis and promote: reduced costs of fertilizer, pesticide, and irrigation water; outreach on how to plant cover crops; early adopters peer-pressure to encourage planting cover crops; demonstration field days on the how-to; cost-share incentives; and changing fallow winter fields to cover crops. Promote loss for gains in implementing conservation practices is the presentation theme.

Lakes and Source Water Protection Synergies

Dan Yates and Tara Gross
Ground Water Protection Council, Oklahoma City, Oklahoma

The concept of Source Water Protection (SWP) is to manage the areas through which water travels. The activities that occur on land and by the downstream flow of waters which, in turn, carry pollutants, sediments, and nutrients into the lake over time play a major role. The direct link between land and water quality is well recognized, and over the past decade successful programs that better connect land use planning and water quality management have been emerging. By working together with water utilities, state and federal regulators, watershed managers, and other water partners, we can protect our source water. We plan to discuss the strategic points of intervention for putting source water protection into the planning process, include (1) long range visioning, (2) plan making, (3) regulations and/or incentives, (4) development project review, and (5) public awareness. The national Source Water Collaborative helps provide the connective tissues between various state, federal, local, and national groups to promote source water protection and bring stakeholders together.

Policies for Protection of Lake Shoreland

Jessica Converse
NALMS policy intern, Olympia, Washington

Lake shorelands play an essential role in the ecological health of aquatic systems. Beginning upland of the lake and continuing into the shallow water, lake shorelands are an ecologically diverse and productive area which provides habitat for both terrestrial and aquatic organisms. In their natural condition, healthy vegetated shorelands moderate the timing, magnitude, and pathways of water, sediment, and nutrient inputs into lakes. However, as this area is altered by lakeshore development, so too are the balances of water flow, soil stability, and nutrient enrichment. In the United States alone, 71% of lakes were considered moderately to highly disturbed by lakeshore development, a number that is expected to increase (United States Environmental Protection Agency 2012). Nutrient pollution not only contributes to the loss of high-quality lakes but exacerbates the release of greenhouse gases (Beaulieu *et al*. 2019) and risk of toxic, algal blooms (Paerl 2017). Protection of lake shorelands now is critical to ensuring they are resilient to these issues which are exacerbated by increasing climatological pressures. Legislation promoting the protection of in-land shores has been enacted, however it is necessary such legislation exists across all states. Additionally, efforts to slow and reverse shoreland deterioration will be more successful if addressed in current early stages of deterioration rather than for lakes that have significantly deteriorated in water quality. It is unlikely these issues can be addressed without additional appropriations to healthy lakes management, underscoring the importance of lake shoreland protection policies for each state as well as restoring Section 314 Clean Lakes funding within the Clean Water Act.

A Crash Course on Algae Management and Prevention in Lakes and Reservoirs

Byran Fuhrmann[1], West Bishop[2], Scott Shuler[3], Mark Heilman[4], Mike Pearce[1], and Greg Armel[2]
[1]EutroPHIX, Whitakers, North Carolina; [2]SePRO, Whitakers, North Carolina; [3]EutroPHIX, Carmel, Indiana; [4]SePRO, Carmel, North Carolina

Algae are an integral part of the aquatic food chain in lakes and reservoirs, but excessive algae growth, also referred to as harmful algae blooms (HABs) can have detrimental effects on aquatic ecosystems and human health. HABs are primarily driven by nutrient input from external sources such as stormwater, agricultural runoff, and point sources, as well as internal nutrient loading from the sediment. Research suggests that urbanization, environmental and land use changes will likely enhance the prevalence of HABs in foreseeable future.

With this in mind, lake managers can utilize both reactive and proactive strategies to reduce the occurrence and negative impacts of HABs. Reactive strategies utilize algaecides to kill the algae that is present without harming other aquatic organisms. Proactive strategies to limit algae growth and proliferation rely on limiting the availability of nutrients. Effective proactive management strategies can reduce or even eliminate the need for reactive management in the future. Recent findings also suggest that the nitrogen to phosphorus ratio is critical in controlling the algae community composition and that managing this ratio can lead to an optimal food web and reduced toxic algae growth. This presentation will cover the core principles of algae management and prevention in lakes and reservoirs using the latest case studies and research. The goal is to provide lake managers with the latest information on the available management options so they can make the most responsible decisions and maintain high water quality without harming the environment or breaking their budget.

The authors of this abstract have a financial interest in the EutroPHIX Division of SePRO Corporation.

Interactive Session F1: JEDI 1

November 18, 2021 | 12:00 pm – 1:30 pm EST

Addressing Societal Challenges With Nature-Based Solutions in Urban Lakes and Watersheds

Gabriella Placido
North American Lake Management Society, Fort Myers, Florida

This year has quickly broken an assortment of records with its extreme weather and unprecedented circumstances. Intense storms, heat waves, fires, floods, droughts, and a series of harmful algal blooms have plagued North America and the rest of the world, all while trying to overcome a persistent and troublesome pandemic. Additionally, urban lakes and watersheds, along with other freshwater ecosystems around the world, are being struck the hardest from human stressors in comparison to other systems. Urban lakes are subject to some of the heaviest use and the most harmful anthropogenic impacts, despite the wide range of environmental, economic, recreational, aesthetic, cultural, and other social benefits they provide to cities and regions. Globally, a growing number of lake managers and urban planners look toward natural processes to solve these environmental and societal issues. Nature-based solutions (NbS) can serve as an important tool in significantly addressing and mitigating many of these concerns, while simultaneously yielding many other valuable benefits. This presentation is based on a NALMS White Paper that I wrote for the NALMS Policy Committee during summer 2021. My paper and presentation argue for increased implementation and prioritization of NbS in urban lakes and watersheds to address some of today's most pressing urban lake management issues. Mutual benefits of NbS include enhancing climate resilience; reversing biodiversity loss; increasing food and water security; and bringing to light environmental justice concerns.

*Cleaning Urban Lakes, but for Whom?

Vinicius Taguchi
St. Anthony Falls Laboratory, Department of Civil, Environmental, and Geo-Engineering, University of Minnesota, Minneapolis, Minnesota

Many urban lakes and their surrounding communities have been historically underserved as a result of systemic and intentional environmental racism. Some of these lakes received exorbitant levels of pollution rendering them hazardous to the health of the communities they once served. Now, following the environmental justice movement, many cities are investing in once divested communities. Frequently involved in these “urban revitalization” efforts are improvements to water resources and implementations of green infrastructure. And yet, the physical, chemical, environmental, and social sciences behind these initiatives are still being developed. Many potential consequences are still emerging. Many others are increasingly understood in their respective fields of study but seldom discussed comprehensively together. In order for project outcomes to be just, equitable, diverse, and inclusive (consistent with JEDI principles), project processes and project teams must be equally just, equitable, diverse, and inclusive. Interdisciplinary teams must be based upon permanent relationships with community partners who are valued and play an active role in the project from its conception. Without meaningful community organization and involvement, sudden improvements to urban lakes and investments in underserved communities is likely to result in rapidly rising property values, rampant gentrification, and eventual community displacement. Critiquing urban lake management approaches now offers an opportunity to ensure that the communities around them will continue to have access.

What Does It Mean to Be Indigenous Led Relationships With Water in a Time of Truth and Reconciliation?

Michele A. Sam
Michele A. Sam Consulting, Ktunaxa, British Columbia, Canada

Living Lakes Canada has embarked upon a formal opportunity to dive deep into how to do differently when it comes to Indigenous Peoples relationships, knowledges and aspirations and is actively focused upon appreciating and contributing to sustaining Indigenous Peoples' place-based knowledge systems regarding water relationships. Indigenous Peoples across the Americas have been mostly excluded from the development of water as a resource, as well as from contributing place-based knowledge to research and program development that is grounded in their roles and responsibilities as stewards of the landscapes and waterways and all living things. Living Lakes Canada is taking active steps towards ensuring the Indigenous Peoples within the Columbia Basin are involved from pre-development and implementation of water programs, in a true partnership endeavour.

A Collaborative Approach to Assessing and Mitigating Stormwater Impacts in the Flathead Basin

Emilie Henry[1], Casey Lewis[2], Kate Wilson[3], and Cassidy Bender[3]
[1]Big Sky Watershed Corps (AmeriCorps), Kalispell, Montana; [2]City of Kalispell, Kalispell, Montana; [3]Flathead Basin Commission, Missoula, Montana

Located in northwest Montana, the Flathead Basin is an economically, culturally, and ecologically vital resource that is anticipated to experience increased threats to water quality in the future. In light of this, the Flathead Basin Commission, a non-regulatory organization formed by the Montana Legislature to protect the basin's water quality, and the City of Kalispell partnered to develop a multi-faceted project that addresses stormwater management and pollution in the larger watershed. As development rapidly advances, the partners recognized that the basin is in a unique position to protect water quality from urban impacts preemptively. Based on a watershed approach to resource management, the Flathead Basin Stormwater Project's first phase included hosting a Big Sky Watershed Corps (AmeriCorps) Member in 2020 to begin the work of gathering information on the state of stormwater in the basin. Phase I focused on inventorying current stormwater infrastructure, management, and ownership and collecting stormwater samples. Through extensive outreach to compile existing data and citizen science data collection events to supplement missing data, a basin-wide map of urban stormwater infrastructure was developed. Stormwater sub-basins were used to generate a model for prioritizing outfalls based on their pollution potential. Phase II of the project (2021) has focused on improving stormwater monitoring techniques, refining and expanding the outfall prioritization model, and framing long-term project objectives to address current and prevent future stormwater problems. The basin-wide approach allows for greater collaboration among partners in the watershed and will ultimately determine the greatest opportunities to reduce and prevent stormwater pollution.

Interactive Session F2: HABs – Monitoring

November 18, 2021 | 12:00 pm – 1:30 pm EST

Proactive HAB Monitoring – T&O and Cyanotoxins

Hunter Adams[1], Sam Reeder[1], Randall Barker[1], Mark Southard[1], Harry Nelson[2], Daniel Nix[1]
[1]City of Wichita Falls, Wichita Falls, Texas; [2]Yokogawa Fluid Imaging Technologies, Scarborough, Maine

This abstract describes the protocol the City of Wichita Falls has implemented to analyze for taste and odor compounds and cyanotoxins in two surface water reservoirs, one holding reservoir, and two water treatment plants. After nearly four years of successful implementation, customer complaints have been all but eliminated. This presentation will provide other water systems with a blueprint for laboratory analyses to create their own protocol.

The City of Wichita Falls, Texas, has designed and implemented a comprehensive integrated rapid monitoring protocol for two surface water reservoirs and one holding reservoir, which includes algae speciation and enumeration by imaging flow cytometry, T&O monitoring by GC-MS/ECD, and cyanotoxin monitoring by qPCR and LC-MS/MS.

By using an integrated laboratory approach to monitoring, the City of Wichita Falls has successfully mitigated several episodes before water containing T&O compounds was discharged to the City's residents. Customer complaints have been all but eliminated. To date, it has been 1,692 days since this new strategy was implemented, with no failures.

Remotely Sensed Cyanobacterial Intensity Predicts Likelihood of Lake Blooms and Toxins Across the Contiguous US

Amalia Handler, Jana Compton, Ryan Hill, and Scott Leibowitz
Pacific Ecological Systems Division, US EPA, Corvallis, Oregon

Cyanobacterial harmful algal blooms (HABs) can produce toxins that impair freshwater ecosystems used for drinking water, recreation, and habitat for aquatic biota. With HABs increasing in extent and intensity globally, water managers need information about how to prioritize lake monitoring. Remote sensing is a promising monitoring tool, but a challenge is connecting satellite data with field bloom conditions across a broad spatial extent. We combined Cyanobacteria Assessment Network satellite data of lakes between 2008 and 2011 with HAB field data from the USEPA's National Lakes Assessments conducted in 2007 and 2012. There were 210 lakes with both satellite data and were surveyed for microcystin toxin, cyanobacteria, and chlorophyll a. We calculated the mean summer bloom magnitude for each satellite-resolved lake and used logistic regression to estimate the likelihood of each lake exceeding the human health risk thresholds of 1.0 µg/L microcystin, 100,000 cells/mL cyanobacteria, or 50 µg/L chlorophyll *a*. In all cases, a unit increase in the lake bloom magnitude was associated with a 15–40% likelihood increase in exceeding HAB thresholds. We used the modeled relationships to predict the likelihood of threshold exceedance for all 2,192 lakes monitored by satellite. Among these lakes, 37–69 were highly likely (> 75% likelihood) to exceed the thresholds. This approach leverages existing national scale data to identify lakes that are at risk for exceeding bloom thresholds that is both geographically comprehensive and grounded in field data. Such analyses are critical for connecting satellite information with field conditions to aid setting monitoring priorities for lake management.

Leveraging Volunteer Water Quality Monitoring Data in the Age of Harmful Algae Blooms

Stephen Souza[1], Barbara Fischer[2], Paul Sutphen[2], and Sean Martin[2]
[1]Clean Waters Consulting, LLC, Ringoes, New Jersey; [2]Normanoch Association, Inc. Frankford, New Jersey

The foundation of a successful lake management program is a robust water quality database. Data are critical to tracking changes in lake conditions, creating a lake restoration plan, evaluating the effectiveness of lake restoration efforts, and especially assessing harmful algae blooms (HABs). Culver Lake, located in Frankford Township, New Jersey is a 550-acre, 65 foot deep, kettle-hole lake. The Normanoch Association, Inc. (NAI) is the owner of Culver Lake.

For the past 30 years NAI has been intricately involved in the routine monitoring of Culver Lake. Starting in the mid-1990s, NAI's Water Quality Committee (WQC) began collecting dissolved oxygen and temperature water column profile data as a means of tracking the operation of the lake's aeration system. Due to the increased concerns with the regional occurrences of HABs, the WQC became increasingly involved in tracking data used to quantitatively evaluate a potential HAB. This includes weekly PC:CHL data monitoring, DO/Temperature profile measurements, Secchi clarity readings and cyanotoxin testing. The WQC volunteer sampling program also involves storm event and tracking possible septic inputs. These "supplemental" data have proven to be both highly cost effective and instrumental in evaluating the lake's ecological status.

This was especially true during the summer of 2020 when the volunteer data were proactively used to predict potential algae blooms or HABs, investigate the ecological drivers of blooms, and communicate HAB related information and risk to the membership. Although the lake at times in 2020 experienced high cyanobacteria cell counts, the WQC's volunteer data, in particular the cyanotoxin data, proved critical in keeping the lake open to recreational use even with the threat of an HAB. Details are provided in this presentation of how these data were collected, interpreted and used on a weekly basis to guide the lake's management and inform the public of the lake's quality.

*Not Adding Up: Cyanotoxins Accumulate Inconsistently Throughout Freshwater Food Webs

Katherine Low and Jim Haney
University of New Hampshire, Durham, New Hampshire

Although most cyanotoxin research focuses on nutrient-rich systems that support persistent cyanobacteria blooms, many cyanotoxins are also prevalent in oligotrophic systems that are less often afflicted by visible blooms. Evidence of cyanotoxin biomagnification in some systems suggests that cyanotoxin exposure risk may be higher than expected based on the clear-water appearance of nutrient-poor lakes. This study aimed to identify potential sources of three cyanotoxins, microcystins (MCs), beta-methylamino-L-alanine (BMAA), and anatoxin-a (ATX) in nutrient-poor lakes in Wyoming and determine how these toxins accumulate in freshwater food webs. From this, we can estimate the risk of dietary cyanotoxin exposure in a variety of wildlife, including frogs, fish, and Common Loons. Trophic relationships were evaluated using stable isotope analysis, allowing for a quantitative comparison of cyanotoxin concentrations across the food web. Overall, we found relatively low concentrations of MCs and ATX in all collected samples. However, BMAA concentrations in benthic and littoral lake regions were comparable with BMAA levels found in other lakes with harmful cyanobacteria blooms. All three cyanotoxins accumulated in consumer tissues (muscle, blood) and tended to be highest in macroinvertebrates. This pattern was strongest for ATX, and weakest for MCs. These results suggest that local wildlife may be at risk of harmful cyanotoxin-related health effects, despite the clear water appearance of lakes in these regions. Furthermore, the observed accumulation of cyanotoxins in macroinvertebrates indicate that cyanotoxins may be spread to nearby terrestrial consumers following the emergence of these insects.

Interactive Session F3: Fundamental Limnology 1

November 18, 2021 | 12:00 pm – 1:30 pm EST

*Variations of Phosphorus Dynamics Between Agricultural and Urban Watersheds and the Impacts on Algal Communities

Benjamin Webster[1], Matthew Waters[1], and Stephen Golladay[2]
[1]Auburn University, Auburn, Alabama; [2]Jones Center at Ichauway, Newton, Georgia

Reservoirs are a growing interest both nationally and globally because of their importance as a water supply to their surrounding communities. This water demand is often exacerbated by the fact that reservoirs service growing transboundary communities. As important as water supply is we cannot lose sight of water quality. Degradation in water quality can be worsened by continued stressors of nutrient loading coupled with the dynamic impacts of climate change increasing the risk of growth of harmful algal groups. Phosphorus, possibly the most impactful freshwater nutrient to primary production, is often considered to enter streams and reservoirs from either point sources (wastewater treatment facilities or other industry) or nonpoint sources (direct landscape runoff like agricultural areas). Over the past century, watershed land use has increased in both urban and agricultural surface areas. Changes to landscape in watersheds have been known to have major impacts on freshwater dynamics. However, there is a knowledge gap of how urban and agricultural dominant watersheds impact reservoir systems differently. Understanding how reservoirs are impacted by anthropogenic phosphorus nutrient loading can be extremely difficult with traditional monitoring techniques. To capture a complete depositional record, we collected paleolimnological sediment cores from multiple reservoirs from both the Chattahoochee watershed (urban dominated) and Flint watershed (agriculturally dominated) to determine alterations in phosphorus deposition as well as variations to algal groups.

Spatial and Temporal Variation of Water Quality in Lake Arcadia, a Central Oklahoma Reservoir

Jonathan West, Lauren O'Donley, Justin Wright, Zach McKinney, Julie Chambers, and Lance Phillips
Oklahoma Water Resources Board, Oklahoma City, Oklahoma

Lake Arcadia is a reservoir located in central Oklahoma that provides many important beneficial uses to the region but has been listed as impaired due to excess chlorophyll *a* and turbidity. We performed a 3-year study (2018–2020) observing the physical characteristics and water quality (*e.g.*, nutrients, chlorophyll a, total suspended solids, and turbidity) at 3 stream sites located in the reservoir's watershed and 5 sites within the lake. Stream sites were sampled approximately once per month during base flow with additional sampling events during periods of high runoff. During each site visit, instantaneous discharge and stage were measured to develop a rating curve and loading estimates for nutrients and sediment. Lake sampling was carried out monthly at each site with an additional sampling trip each month during the growing season (May to September) along with a temperature and dissolved oxygen profile. In addition, a temperature string attached to a buoy was installed at the site nearest the reservoir's dam to observe lake stratification and turnover throughout the study period. Variation in water quality was greatest during high runoff events in the streams and was also observed at the riverine site in the reservoir. Thermal stratification in the lake set up in late March to early June each year and resulted in anoxia below the thermocline with a buildup of nutrients such as phosphorus and ammonia. These data will be helpful in developing models in order to assess water quality impairments in this lake and in understanding reservoir dynamics within the state.

Dynamics of Anoxia and Lake Stability Revealed From High Frequency Vertical Profiling in a Hypereutrophic Polymictic Reservoir

Nicole D. Wagner, Caleb J. Robbins, Stephen M. Powers, and J. Thad Scott
Center for Reservoir and Aquatic Systems Research and Department of Biology, Baylor University, Waco, Texas

High-frequency water quality monitoring is growing rapidly in freshwater research and management. Sensor deployments in naturally formed lakes, often at a fixed depth, dominate the current understanding of ecosystem dynamics with comparatively few studies focusing on reservoirs. Here, we examined the effects of wind speed and direction on the stability and oxygen dynamics in a Central Texas hypereutrophic reservoir. We used an autonomous water quality monitoring profiler that recorded temperature, dissolved oxygen, pH, and conductivity water quality variables and wind speed, wind direction, and air temperature from an on-platform mounted weather station. Data was collected every two hours from April 25 to November 20, 2019, with each profile spanning surface to 10 m depth with 0.5 m steps. Throughout most of the sampling period, the lake did not have a thermocline. However, an oxycline occurred throughout most of the monitoring period, with multiple mixing events noticed. Short periods of anoxia near the sediment were first observed in May, with chronic anoxia between July and September. We identified two brief periods of anoxia throughout the whole water column in late August and early September. Surface dissolved oxygen measurements for each two-hour interval were highly synchronous with Schmidt's stability. During decreasing and low Schmidt's stability, the oxycline destabilizes in association with changes in wind direction and speed. Our results indicate that dissolved oxygen concentrations are highly dynamic in a polymictic reservoir that could influence internal nutrient cycling on daily timescales.

Interactive Session F4: Applied Limnology 1

November 18, 2021 | 12:00 pm – 1:30 pm EST

Mechanical Destratification of Large Water Bodies: History and Prospects

Tom C. Hausenbauer
Limnetics Corp., Mishawaka, Indiana

Mechanical destratification is a method using high volume pumps to reduce or eliminate stratification of ponds, lakes, and reservoirs. Potential advantages include:

(1) Delivery of oxygen to sediment-water interface to create oxic condition. This can result in:

a. Drinking water taste improvement by trapping of metals in sediment;

b. Odor control by suppression of hydrogen sulfide production;

c. Decrease in internal loading of phosphorous.

(2) Phytoplankton species composition shift away from buoyant cyanobacteria by limitation of light.

The technique is being used successfully in small water bodies (< 100 ha) worldwide. Application to larger water bodies has been less practical due to the large number of machines needed. Research on larger machines began at Oklahoma State University in the 1970s, demonstrating impellers up to 5 m diameter in a 950 ha Lake. Further study in the 1980s by the Army Corps of Engineers resulted in empirical equations to predict plume depth and demonstrated the horizontal spread of a warm oxic plume below the thermocline. High flow (> 1000 l/sec) mechanical destratifiers are commonly used in Illinois drinking water reservoirs as an inexpensive alternative to chemicals in removal of metals. This presentation addresses the state-of-the-art in mechanical destratification, with focus on larger machines. Topics include available equipment, limitations, pros, cons, economic comparison with other options, and needs for development of predictive science. Multiple sample dissolved oxygen profiles compare mechanically destratified reservoirs with natural stratification.

Financial Interest Disclosure: The author / presenter, Tom C. Hausenbauer, P.E., is the principal owner of Limnetics Corp., a manufacturer of mechanical destratifiers and other equipment for circulation of lakes and reservoirs.

Measuring the Impacts of Wake Boats: A Pilot Study From East Pond

Danielle Wain
7 Lakes Alliance, Belgrade Lakes, Maine

Surfing behind wake boats is growing in popularity, particularly with summer camps. Many of our lakes have seen an increase in this type of boating activity. The potential water quality impacts of wake boats include (1) erosion of sediments beneath the prop wash and (2) shoreline erosion from the large waves produced. In 2018, the 7 Lakes Alliance, East Pond Association, and partners conducted an alum treatment on East Pond in Maine (700 ha, maximum depth = 8 m, mean depth = 5.5 m). This study was initiated in response to concerns that wake boats might impact the longevity of the alum treatment. In August 2019, with the assistance of Camp Manitou, an experiment was designed to test the depth of penetration of the wakes to determine the likelihood of bottom resuspension. To measure the boat wakes, a 1-MHz pulse-coherent acoustic Doppler current profiler (ADCP) was placed by divers on the bottom of the lake at the deepest point. Camp Manitou ran the same boat configured in three ways (surfing, extreme wakeboarding, and water skiing) over the ADCP. When the boat was configured for surfing, the wake penetrated approximately 2 m, compared with only 1 m in other configurations. While this work shows that it is unlikely that wake boat activity will directly stir up treated sediments at East Pond, there is still future work to be done to determine the impact of wake boats on water quality.

Phosphorus Flocculation: On-Shore and In-Lake Phosphorus Removal With Anionic Polyacrylamide

Kyla Wood
Applied Polymer Systems, Inc., Marquette, Michigan

Anionic polyacrylamides (PAMs) are versatile and effective flocculants that are widely used for erosion control and water treatment in agriculture, construction, stormwater, drinking water, and wastewater. PAMs can remove a wide variety of contaminants from water including sediments, metals, and nutrients. PAM's ability to flocculate phosphorus and high margin of safety for sensitive aquatic organisms make them a valuable treatment option for ponds and lakes that have been degraded due to excess nutrients. PAM log technology has been used in ponds in lakes for nearly a decade and can remove 60–90% of phosphorus from the water column. However, flocculation is a process that requires moving water and vigorous mixing; therefore, PAM logs have historically been limited to use in systems with aerators, fountains, waterfalls, and other water moving apparatuses. A solution to this is portable, onshore flocculant introduction and mixing systems that have grown in popularity and effectiveness in recent years. This presentation will discuss both onshore and in-lake treatments with anionic PAM. Specifically, results of a field trial using an onshore, PAM introduction and mixing system will be highlighted. This 2020 study resulted in 90%, 80%, and 73% decreases in turbidity, phosphate, and iron, respectively. The setup, maintenance, and troubleshooting that was involved in this PAM treatment will also be detailed.

The author(s) of this abstract has/have a financial interest in PAM.

Breaking Down Stratification–How Understanding Lake Stratification Can Affect Lake Management

Anne Wilkinson
Stantec, Minneapolis, Minnesota

Thermal stratification affects many lake processes and is quite easy and inexpensive to measure. Stratification influences physical mixing, interaction between the epilimnion and hypolimnion, and lake turnover. This presentation will outline how stratification strength, build up, and breakdown are correlated with harmful algal bloom distributions, anoxia and internal loading release, and entrainment between the hypo and epilimnion. Continuous long term high frequency monitoring has allowed us to understand the relationship between thermocline depth, stratification strength and a) harmful algal blooms (HABs) vertical distribution b) anoxic depth and c) nutrient entrainment across the thermocline. We will also highlight how stratification affects lake management decision making, *i.e.*, water quality monitoring plans, intake depth, and internal loading controls. We will conclude with options for stratification monitoring and the associated cost of different monitoring techniques.

Interactive Session G1: JEDI 2

November 18, 2021 | 2:00 pm – 3:30 pm EST

Urban Lake Restoration Challenges – Getting More Even When Faced With "LES"

Stephen Souza
Clean Waters Consulting, LLC, Ringoes, New Jersey

Urban lakes are unique water features, often serving as community destinations and hubs, analogous to an "oasis within a concrete desert". Being shallow and fed mostly by stormwater runoff, the morphometry and hydrology of urban lakes makes them more susceptible to water quality impairments and hypereutrophication. This puts these lakes at a much greater risk of experiencing harmful algae blooms. Although many urban lakes are not "swimming lakes", on a per areal unit basis and per user unit basis, urban lakes are often even more extensively utilized than the larger "recreational" lakes that receive the majority of lake management funding and lake restoration research. Additionally, urban lakes are most often used by communities of color and overburden communities, leaving these communities with waterbodies incapable of meeting community needs and expectations.

The challenges faced by lake managers working to improve urban lakes can be categorized as a problem of "LES"; that is Legacy, Environmental and Societal issues that hinder the attainment of lake management goals and achievement of significant and sustainable water quality improvements. Legacy issues relate to historical pollutant inputs, as well as a history of insufficient representation and lack of funding. Environmental issues pertain to poor source water quality, intermittent inflow dominated by stormwater runoff and physiochemical features which promote HABs. Finally, societal issues pertain to systemic discrimination and environmental justice issues that impact the ability to meet the community needs of those that rely on and make use of urban lakes.

This presentation will discuss not only the challenges of doing more even with faced with LES, on "what to do" focusing on a) education and outreach, b) importance of increasing funding for urban lakes, c) implementation of stormwater management and proven in-lake restoration measures, and d) most importantly engagement of the community and community leaders to take on a more proactive role in caring for these urban treasures."

Summer in the City? Temperature Variability in Urban Lakes Compared to Other Land Use Types in a Global Set of Lakes

Patrick Kelly[1], Abby Lewis[2], Maddie Chandler[3], Kathleen Cutting[3], and Amanda Cheang[3]
[1]Department of Biology, Rhodes College, Memphis, Tennessee; [2]Department of Biological Sciences, Virginia Tech, Blacksburg, Virginia; [3]Environmental Science and Studies, Rhodes College, Memphis, Tennessee

Multiple studies have demonstrated lake surface temperatures have been increasing worldwide over the past several decades, likely due to rising atmospheric temperatures. Lakes that are located within urban landscapes may be warming faster as impervious surfaces distribute a water load that is warmer than would be found in forested watersheds, and urban heat islands may contribute to warmer air temperatures compared to more vegetated habitats. In addition, stratification patterns in urban lakes may show distinct variability compared to lakes in watersheds of other land use types, as mobilization of colored DOC or sediment is likely to show less variability than forested or agricultural areas. We used a global survey of lake surface temperatures and temperature profiles to determine rates of change in surface temperatures and stratification dynamics in urban lakes vs. lakes in watersheds of other dominant land use types. While we hypothesize urban lakes should respond more to observed changes in climate, early returns suggest rates of lake warming are less impacted by watershed land use type than morphological features including lake size. However, our dataset highlights a glaring need to include urban systems in global data collection efforts to better understand how these economically and socially important systems are being impacted by global change.

The Ecological and Economic Value of Lakes in Mitigating the Urban Heat Island Effect

Laura Costadone and Mark Sytsma
Portland State University, Portland, Oregon

Rapid urbanization and climate change are exacerbating the negative consequences of the urban heat island effect (UHI). Nature-based solutions can mitigate these negative effects and help guarantee a sustainable and livable urban environment. Evaporative cooling by lakes could be one such solution, particularly in hot and dry climates. The aim of this study was to evaluate the ecological and economic impact of artificial lakes in mitigating the UHI phenomenon under current conditions and future climate change scenarios. We quantified the energy savings provided by artificial lakes within the Phoenix, Arizona (USA) Metropolitan area. The influence of lakes in mitigating the UHI was compared to three alternative land use/land cover types: a city park, and low-density and hi-density development urban scenarios. Our results showed that the presence of a lake significantly mitigated the air temperature and reduced electricity consumption. The potential to moderate air temperature was most evident within 250 m of the lake. The heat reduction service provided by a lake could contribute an energy savings up to 57.1% with respect to the scenario characterized by high-density development. During the hottest months of the year houses adjacent to a lake could save up to 70% in electricity consumption compared to houses within a buffer zone 750 m from the lake. Our results indicated that the presence of a lake could also be beneficial in mitigating increased temperatures forecasted by climate change scenarios. This research can inform decisions on sustainable urban planning and water use in a desert city.

Interactive Session G2: HABs – New Technologies

November 18, 2021 | 2:00 pm – 3:30 pm EST

*Establishing Norms for Phycocyanin Levels in Lakes of Northeast Pennsylvania – A First Step in the Progression Towards a Harmful Cyanobacteria Bloom Threshold

Lauren A. Knose, Erin P. Overholt, and Craig E. Williamson
Miami University, Oxford, Ohio

Lake managers are employing numerous technologies to monitor cyanobacteria in lakes, to better predict and monitor harmful cyanobacteria bloom (HCB) events. One technology widely employed is using submersible sensors to measure pigments produced by cyanobacteria, predominantly phycocyanin (PC) and chlorophyll (Chl). PC biomass strongly correlated with cyanobacteria cell density in laboratory studies and has been used to estimate total cyanobacteria biomass. Submersible PC sensors have been deployed in lakes for 15 years, yet HCB advisory thresholds for PC have not been published as there are for Chl. There are comprehensive published reviews that speak to the challenges with accuracy of the data from in situ PC sensors, such as physiological variability in pigment production, complexity of the phytoplankton community, physical influence of light, temperature and other fluorescent material on the signal, and difficulty in adequate calibration of sensors and interpretation of the data. Further, the range of measured PC and reported units restricts the ability to determine typical levels of PC among lakes. The purpose of this study was to take the first step by establishing typical PC levels in an oligotrophic, eutrophic, and dystrophic lake, located in Northeast Pennsylvania. Five years of vertical profiles of PC fluorescence, taken monthly during the ice-off season, were analyzed. Monthly in situ PC fluorescence was compared to extracted pigment measured via spectrophotometer in the epilimnion, metalimnion and hypolimnion. The findings from this study will help further the progress of developing HCB thresholds for PC in lakes in the region.

Superior Lake Management With RNA Technologies

John Higley
EQO Inc, Austin, Texas

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

The authors of this presentation have a financial interest in the product described.

*Rapid HAB Toxicity Testing Made Simple

Nicholas Panyard[1] and Charles Kozora[2]
[1]OTT HydroMet, Houston, Texas; [2]OTT HydroMet, Cranberry Township, Pennsylvania

The inception of the harmful algal bloom detection and monitoring solution LightDeck MINI began with funding by the US National Science Foundation. It included active collaboration with teams from NOAA-Charleston, Bowling Green State University, and Bigelow Laboratory for Ocean Science, to name a few.

Developed with dedicated collaborators and funded by scientific, academic partners, and federal agencies, the system instrumentation consists of two components for the Early Detection of Harmful Algal Bloom Toxins. It precisely measures microcystins (MC) and cylindrospermopsins (CYN).

End-users can expect a workflow similar to strip tests but with results that demonstrate sensitive detection comparable to ELISA. The system will now have a fully developed and validated rapid, portable, low-cost multiplexed cyanotoxin detection system, which can go from bloom to cell lysis and detection in less than 20 minutes.

Interactive Session G3: Fundamental Limnology 2

November 18, 2021 | 2:00 pm – 3:30 pm EST

Communicating the Cycle of Lake Management to Make Sure Your Plan Doesn't RIP

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

A significant obstacle to overcome in the management and restoration of public and private lakes is the stakeholder desire to quickly implement projects "on the ground" that show immediate water quality benefits and "fix" the lake. In many cases, financial resources and patience required to clearly define the problem and develop a comprehensive, targeted, and adaptive long-term plan are lacking. This can result in ineffective actions resulting from Randomly Implementing Practices (RIP), which in turn, can kill momentum and progress. The purpose of this presentation is to propose a systematic approach for lake management that (i) demonstrates the importance of individual steps in a potentially cyclical process, (ii) provides ideas for managing stakeholder expectations, and (iii) offers a phased approach for dealing with the inherent uncertainty of lake management.

The major steps in the cycle include defining the problem, developing suitable/tangible metrics, quantifying pollutant fluxes and lake response, identifying a menu of strategies to prioritize and sequence, designing and implementing high priority alternatives, and continuously monitoring and adjusting the adaptive plan. These steps should be centered around a stakeholder outreach and involvement process that aligns technical and funding resources and partners, sets appropriate expectations, uncovers community concerns or controversies, and gathers important feedback. Real-world examples of the consequences of "step-skipping" will be discussed and include loss of project support, development, and design of un-implementable alternatives, and wasted resources.

Gauging the Health of Vermont Lakes Using 2007 and 2012 National Lake Assessment Findings

Leslie J. Matthews and Kellie Merrell
Vermont Department of Environmental Conservation, Montpelier, Vermont

Vermont participated in EPA's 2007 and 2012 National Lake Assessments (NLA) at the overdraw level. In both 2007 and 2012, in addition to sampling the 10 lakes in Vermont that were included as part of the national assessment, Vermont sampled another 40 randomly selected lakes, using the same protocols as the national survey. This provided sufficient sample sizes to allow assessment of the overall conditions of Vermont's lakes, as well as direct comparisons of the condition of Vermont's lakes to those of the Northern Appalachian (NAP) ecoregion and the nation. Results from the 2007 NLA revealed that the most important stressor impacting Vermont lakes was degraded physical habitat. In contrast, Vermont lakes were less impacted by nutrient enrichment. Only 7% of Vermont's lakes were rated in poor condition for total phosphorus. However, an analysis comparing data from the 2007 and 2012 National Lake Assessments (Stoddard *et al*., Env. Sci. and Tech., 2016) suggested that total phosphorus in lakes may be increasing on a continental scale, especially in historically oligotrophic systems. In addition, other studies (Matthews *et al*., LakeLine, 2018) suggest significant increases in phosphorus in Vermont's oligotrophic lakes. Results derived from Vermont's participation at the overdraw level in the 2012 NLA will be presented and compared to results from the 2007 assessment to determine whether Vermont's condition assessments changed significantly between the two surveys. We will explore whether Vermont's phosphorus results mirror the apparent increases occurring at the national scale. In addition, results will be compared to the 2012 results from the NAP ecoregion and nation.

How Anoxic Is Anoxic, Estimating Dissolved Oxygen Demand After It Has Been Fully Exhausted From the Hypolimnion of a Eutrophic Lake

George Knoecklein
Northeast Aquatic Research, Mansfield Center, Connecticut

Benthic respiration has traditionally been assessed by the change in dissolved oxygen content of hypolimnetic water (Hutchinson 1938). This oxygen deficit approach works well in cases where the lake is deep enough for the complete aerobic decomposition of biomass in the water column and when the volume of dissolved oxygen in the deep water exceeds the mass of organic matter supplied to it (Charlton 1980b). When neither of these are the case hypolimnetic water is rapidly depleted during the spring, restricting the time when dissolved oxygen deficit measurements can be made to a few weeks in the early spring. However dissolved inorganic carbon has been shown to continue increasing in the anoxic water (Rich 1975) meaning that decomposition of organic matter continues anaerobically leading to an oxygen debt. This paper examines one possible way of estimating the dissolved oxygen demand in anoxic water by combining accumulation dissolved inorganic carbon, and the dominant Alternate Terminal Electron Acceptors (Donors), iron, manganese, and sulfur, and the resulting increased charge to the environment (Eh). This paper examines how anaerobic respiration leads to the accumulation of reducing power in the sediments each season, suggesting that on-set of anaerobic respiration at the bottom of lakes represents the beginning of internal loading and eventual irreversibility (Carpenter *et.al*. 1999), because of the holdover and accumulation of reducing power from one year to the next.

Exchange Between Two Basins Through a Narrow Bay in an Unstratified Chautauqua Lake, New York

Guillaume Auger[1], Vincent Moriarty[1], Michael Kelly[1], Courtney Wigdahl-Perry[2], and Harry Kolar[1]
[1]IBM Research T.J. Watson, Yorktown Heights, New York; [2]SUNY Fredonia, Fredonia, New York

Satellite images of Chautauqua Lake, one of the westernmost lakes in New York State, shows a clear dichotomy between the south basin with nutrient-rich water and the north basin with clear water. Recent research on cyanotoxin concentrations in the basins shows that toxins are more abundant in the northern basin with more biomass during bloom events as opposed to the south basin that is eutrophic.

We investigate the exchange between the north and south basins through Bemus Bay using a validated hydrodynamic model. Two cases are simulated, a period when the start of Harmful Algal Bloom (HAB) was visually observed in the north basin and a period when a HAB was not observed.

In both periods, an Empirical Orthogonal Function (EOF) decomposition of the flow at the north end of Bemus Bay shows that about 81% of the flow's variance can be explained by a two-layer flow correlated with the northward component of the wind at that location. In the south end of the bay, the EOF decomposition indicates that 61% of the variance can be explained by a two-layer flow and 33% of the variance can be explained by surface-seiche induced currents.

Through numerical modeling, we show that in Chautauqua Lake, even with northerly winds, there is an exchange of material from the south to the north deeper in the water column.

Interactive Session G4: Applied Limnology 2

November 18, 2021 | 2:00 pm – 3:30 pm EST

The Impact of Alewife Introduction on Water Clarity

Kenneth Wagner
WRS, Inc., Wilbraham, Massachusetts

Re-establishing alewife spawning runs in New England lakes where they have been absent for a century or more is one of many valid goals of water resource management. Alewife fuel potential trophy gamefish production, support fish-dependent birds such as loons, and are an important part of the marine food web. As anadromous fish, alewife need freshwater lakes to spawn and dam construction has historically reduced access, leading to more recent efforts to re-establish those runs by dam removal, fishway construction, or more laborious transfer of fish around obstructions. However, alewife propagation is only one of many goals and has distinct negative impacts that should be considered. Major decreases in the biomass and mean body size of zooplankton are routinely observed, limiting food resources for planktivorous fish, including young gamefish that are supported by alewife as adults. Zooplankton community depression by alewife limits grazing capacity on algae and leads to lower water clarity in lakes with alewife runs. This loss of clarity is directly related to lower biomass of zooplankton, especially Daphnia, which consume algae and enhance clarity in lakes without alewife. Abundant panfish populations can have a similar impact, but the nature of alewife runs leads to more severe summer zooplankton community impacts. Lakes with alewife will therefore have the highest algal biomass and lowest clarity possible for the level of fertility offered by the lake. Alewife re-introduction requires a very aggressive nutrient control program to minimize impacts on algae abundance and water clarity.

*Wind Sheltering in Stormwater Ponds and Management Implications

Vinicius Taguchi[1], William Herb[2], John Gulliver[1], Jacques Finlay[3], and Ben Janke[3]
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Maintaining an oxic water column is crucial to preventing sediment phosphorus release in stormwater ponds. Wind-mixing is the primary mechanism of aeration in most urban stormwater ponds, but relationships developed for lakes do not accurately describe dynamics in ponds. Urban stormwater ponds and other small waterbodies are highly sensitive to shoreline wind sheltering from trees, structures, and topography due to their already limited wind exposure from their short fetches (distance from one shore to another in the direction that wind is blowing) relative to larger lakes. Once the wind-surface boundary layer has been disturbed by shoreline sheltering, the shear stress that can be imparted upon the water surface is greatly reduced. By coupling a 3D computational fluid dynamic model (FLUENT) with a 2D hydraulic and hydrologic model (CE-QUAL-W2), we are exploring the effect of different wind sheltering conditions on stratification in urban stormwater ponds depending on pond characteristics. Modeling different ponds has enabled us to quantify the wind sheltering that each experiences. Modeling different sheltering reduction strategies has also allowed us to find the most efficient (maximum wind exposure with fewest trees removed) for each pond. For example, clearing narrow corridors along the most frequent wind direction reduces sheltering substantially. The benefits of such an approach can be evaluated both qualitatively and via cost-effectiveness.

Evaluation of Zero Valent Iron for Phosphorus Reduction, Spanaway Lake, Washington

Alex K. (Sandy) Williamson[1] and Jeffrey H. Tepper[2]
[1]Friends of Spanaway Lake (retired USGS), Tacoma, Washington; [2]Geology Department, University of Puget Sound, Tacoma, Washington

Spanaway Lake, a natural 270 acre kettle lake near Tacoma, Washington, is experiencing more frequent hazardous algal blooms (HAB) and increased nuisance aquatic plant growth. The lake (z_{avg} = 16 ft) is dominantly (~65%) groundwater fed, with an estimated residence time of < 6 months. It is P-limited and classified as mesotrophic with total phosphorus (TP) ~20 µg/L. Flux measurements and hypolimnion monitoring indicate P release from bottom sediment is minimal, but TP of surface water and groundwater upgradient from the lake ranges from 20–40 µg/L due to septic tank effluent. Groundwater vents near the edges of the lake (≤ 3 m water depth) appear to be a significant source of P loading. These are recognized by low DO, 2–6 °C water temperature difference in summer and winter, and elevated P (TP up to 74 ppb). The continuous delivery of P-rich groundwater and short residence time pose a challenge for some traditional HAB mitigation methods. We are evaluating zero valent iron (ZVI) as an economical and environmentally safe means of treating P-rich groundwater as it enters the lake. Application of median 125-micron ZVI has reduced Phosphorus in microcosm and other small-scale tests. We will be testing 5-micron ZVI for water stripping of P. We will also be comparing ZVI results with Phoslock results.

Building Climate Change into Lake Management Efforts in Small Rural Watersheds

Jeremy Williamson[1], Joe Magner[2], Udai Singh[3], Tim Larson[4], Leslie Ludke[5], and Cassondra Cavegn[2]
[1]Williamson and Associates, Amery, Wisconsin; [2]University of Minnesota Bioproducts and Biosystems Engineering Department, St. Paul, Minnesota; [3]Mississippi Watershed Management Organization, Minneapolis, Minnesota; [4]Pipe & North Pipe Lakes Protection and Rehabilitation District, Comstock, Wisconsin; [5]Plant and Earth Science Department, University of Wisconsin-River Falls, River Falls, Wisconsin

North Pipe and Pipe Lakes located in Northwest Wisconsin are mesotrophic and oligotrophic lakes that may be changing with changes in precipitation in the midwestern USA. A lack of understanding about hydrologic pathway and processes for lakes lead to uncertainty of water quality impairment causes and concordant difficulty in managing contributing areas of nutrients. Typically, a watershed with nearly 100% forest cover yields little surface runoff, unless soils have been disturbed or evapotranspiration has been reduced. This is particularly true with the large magnitude summer storms that have passed over North Pipe and Pipe Lakes over the past decade.

We hypothesized that water would infiltrate and recharge groundwater and that 30 to 50% of the lake water budget would be comprised of groundwater; however, temperature measurements in lake littoral zones and stable isotopes of hydrogen (δD) and oxygen ($\delta^{18}O$) suggest that groundwater inflow is small, Direct precipitation and storm runoff drove the 2019 and 2020 isotopic results. Further in the summer of 2019 a major blow-down uprooted thousands of trees creating more open areas. With fewer trees transpiring water, more overland runoff likely occurred transporting fine sediment and phosphorus. Based on the plotting of 2019 and 2020 $\delta^{18}O$ and δD data, we focused our 2021 data collection on measuring flows and concentrations in 10 small tributaries and direct precipitation measurements. We anticipate building a comprehensive water and biogeochemical budget for North Pipe and Pipe Lake and use results to mitigate climate change through adaptive management strategies.

General Sessions

General Session 1A: Citizen Science 2

November 16, 2021

Source Water Protection: Engaging the Public Through Secchi Day, a Citizen Science Program on Beaver Lake, Arkansas

Matthew Rich
Beaver Water District, Lowell, Arkansas

Beaver Lake, a man-made reservoir in Northwest Arkansas, is the drinking water source for about 420,000 Arkansans. Beaver Lake is under constant threat of water quality degradation from increased sediment load, point source contamination, increased urban and agricultural runoff, etc. Source Water Protection (SWP) programs seek to protect source water from these threats using a holistic, collaborative approach involving water utilities, lake managers, stakeholders, and citizen groups. Here, we address one aspect of our SWP program, citizen science engagement via 'Secchi Day on Beaver Lake.' Understanding long-term water quality parameters (Secchi depth, concentrations of chlorophyll *a*, total phosphorus, and nitrate) along this ~ 80 km transect is expensive and labor-intensive. To address this, Beaver Water District has held its annual Secchi Day on the second Saturday in August since 2006. Throughout the 15 years, 457 volunteer boat teams sampled 36 lake sites in duplicate, while thousands of citizens have attended an associated water science festival. Survey results from participants indicate that 72% of attendees reported learning something new about their drinking water source, while > 85% reported that they would likely attend in the future and would likely tell others about Secchi Day. Furthermore, we address the benefits of engaging the citizenry in an effort to promote buy-in towards our overall goal of SWP and discuss trends in water quality for the past 15 years in Beaver Lake.

General Session 1B: Managing Oklahoma Lakes

November 16, 2021

Comparing Spatial Autocorrelation and Biases in Data From Two Site-Selection Methods Used in Oklahoma's Nonpoint Source Stream Monitoring Program

Joseph Dyer and Dan Dvorett
Oklahoma Conservation Commission, Oklahoma City, Oklahoma

Differences in monitoring objectives have led to theoretical differences in the proper methods for selecting stream monitoring sites. Non-randomized, targeted sampling has understandably been criticized as being statistically biased and unrepresentative of the broader landscape. However, a probabilistic approach to site selection is not well-suited to our objective of identifying impaired watersheds at a scale optimized for implementation of conservation practices for water quality improvement. We explore spatial autocorrelation in nutrient and fine sediment loads and indices of biotic integrity from 210 targeted and 234 probabilistic sites to determine whether our targeted site-selection introduces biases in assessment of stream condition at a broad scale. First, we tested regional data for spatial autocorrelation using Moran's I test, because a primary reason for randomized sampling is to avoid autocorrelation. Next, we used logistic regression to determine whether we were more or less likely to assess a stream as good or poor given the site-selection methodology. Spatial correlation was present for each of the four variables tested. However, we were able successfully model and remove spatial autocorrelation from the analyses. With spatially correlated errors removed, only fine sediment loads were significantly different between targeted and probabilistic sites. Although we were unable to determine the reason for differences in fine sediments, difference in the stream order of targeted and probabilistic sites is likely important. We determined that our targeted data are representative of the broader landscape, but the narrow range of stream orders represented by targeted sites should be considered moving forward.

*Design and Development of a Water Observatory: An Autonomous Environmental Sampling System for *In situ* Sensing of Lakes and Rivers

Muwanika Jdiobe and Jamey Jacob
Oklahoma State University, Stillwater, Oklahoma

This project focuses on the design, development, and implementation of an autonomous system, or unmanned surface vessel (USV), known as MANUEL (Mobile Autonomously Navigable USV for Evaluation of Lakes). MANUEL is an autonomous boat that can monitor water quality in lakes, rivers, and reservoirs to monitor modern-day pollution from industries and run off from agricultural farmlands into lakes and rivers. The USV can be coupled with an unmanned aircraft system (UAS) to collect data and enhance the water quality sensing capabilities. The surface vehicle is a single meshed W-V-shaped hull for improved stability and operability in all weather and wave conditions including turbulent water and strong winds. MANUEL is powered by two electric driven thrusters providing enhanced maneuverability and it is controlled using an Orange Cube Pixhawk V.2.0. as the autopilot.

MANUEL measures water quality parameters using its embedded sensor probes that are in direct contact with the water. Critical water quality parameters include water temperature, dissolved oxygen, chlorophyll, pH, turbidity, conductivity, salinity, and depth as well as nutrients of the body of water. The data collected is stored on board. Using digital maps and GPS, MANUEL can autonomously map an entire lake with no human intervention, even in conditions unsuitable for humans such as high winds or storms. After the autonomous mission, the data is retrieved from MANUEL, analyzed using MATLAB to map the observed parameters, and builds prediction models for the water quality of the body of water and the corresponding water shed.

Boomer Lake, Lake McMurtry, and Grand Lake in Oklahoma have been used as test sites. At the Grand Lake, MANUEL is currently monitoring and surveying the water quality to better understand and prevent Harmful Algal Blooms (HABs).

15 Years of Monitoring Mercury in Fish in Oklahoma: What Have We Learned?

Jay Wright and Brian Magott
Oklahoma Department of Environmental Quality, Oklahoma City, Oklahoma

In 2007 ODEQ began a program monitoring fish tissue for mercury to evaluate the safety of eating fish from Oklahoma lakes. Originally, largemouth bass were targeted as an indicator species at 50 lakes throughout the state. Based on those initial results, the program has since evolved to include the collection and analysis of multiple sportfish species at 95 reservoirs resulting in the provision of detailed safe consumption advice to the public. Data gathered shows patterns in the distribution of mercury in fish. Recently published information provides insight into the sources of mercury contamination, its biochemical transformation, movement through the foodweb, and risk assessment. Challenges and opportunities for the program going forward are identified.

2020 Lake Thunderbird Monitoring and Analysis

Curt Dikes
Oklahoma Water Resources Board, Oklahoma City, Oklahoma

The Oklahoma Water Resources Board (OWRB) has worked with the Central Oklahoma Master Conservancy District (COMCD) for more than 20 years to provide water quality monitoring and analysis at Lake Thunderbird, creating a long-term dataset to assist the COMCD in making lake management decisions. Lake Thunderbird is an important water supply lake that serves several Oklahoma City metro area communities. Due to its proximity to developed urban landscape, the reservoir has suffered from increased eutrophication due to nutrient loading. This presentation will cover monitoring efforts conducted during the 2020 sample year and additional studies underway on the reservoir.

General Session 1C: Method Development

November 16, 2021

Intercepting Nutrients in Inflows With a Novel Filtration Technology

West Bishop[1], Byran Fuhrmann[2], Scott Shuler[3], and Mark Heilman[4]
[1]SePRO, Whitakers, North Carolina; [2]Eutrophix, Whitakers, North Carolina; [3]Eutrophix, Carmel, Indiana; [4]SePRO, Carmel, Indiana

Rising populations have led to substantial increases in nutrient input to aquatic systems from both urban and agricultural runoff. While watershed management techniques can limit this input, they have largely failed to keep up with ever-increasing nutrient loading. This presentation provides case studies and an overview of EutroSORB®, a novel new phosphorus filtering technology, which is designed for use in flowing waters and may serve as an effective buffer to limit nutrient input from runoff. EutroSORB® is an all-natural formulation which rapidly and selectively binds phosphate from many types of water and is very effective at short contact times across various flow rates. EutroSORB® can effectively remove more than 10 mg of phosphorus per gram of material (> 1%) which allows small filter bags to treat large volumes of water or waters with high phosphorus concentrations. EutroSORB® media can also be used as a soil amendment to enhance the quality of soils after the phosphorus binding capacity has been exhausted. Since nutrients are a key driver of eutrophication in freshwater systems, and as inflow or "recharge" of nutrients is a key factor limiting longevity of in-lake controls, intercepting nutrients in these inflows is a critical need in water resource management.

The authors of this abstract have a financial interest in the described presentation. iv) EutroSORB® is a trade or brand name and registered trademark of SePRO and is ii) a commercial product.

Comparing Secchi Disk Depths With and Without a View Scope in Northeastern Lakes

Kendra Kilson, George Knoecklein, Alejandro Reyes, and Hillary Kenyon
Northeast Aquatic Research, Mansfield Center, Connecticut

Water clarity as measured with a Secchi disk is one of the most commonly used parameters to assess lake trophic state, dating back to 1865. However, beyond the standardization of the size of the disk size at 20 cm and reflective surface as having white and black quadrants, no other aspects have been standardized, leading to incomparable results. This presentation looks at the use of a view scope to improve the resolution of the disk's disappearance depth. A view scope eliminates error due to surface reflectance and scatter by placing the observer's eye below the surface of the water.

We measured Secchi disk depth with and without a view scope at over 30 lakes in New York, Connecticut, and Massachusetts in 2020 and 2021. Lakes ranged the full spectrum of trophic state and size. The goal of the study was to determine if the view scope improved the depth of the readings. Preliminary results show that the view scope increases the Secchi disk depth proportionally to the clarity of the water. That is, the view scope showed little to no improvement at clarities < 2 m but showed greater improvement with increasing clarity above 3 meters. When water clarity is > 5 meters improvements as large as 2 meters have been noted. Due to the linearity of the relationship the percent error by not using a view scope can be estimated at greater water clarities than represented by our data set, as well as a correction factor of reading made without a view scope.

Smoke Alarms for HABs: New Technologies and Case Studies

Christopher Lee, Kara Wolley, and Patty Laushman
AquaRealTime Inc, Boulder, Colorado

Whereas full characterization of a waterway's health is ideal for research and modeling purposes, there are also many scenarios where stakeholders need a simple and affordable way to remotely detect algae blooms before they progress into full blown HABs, basically a smoke alarm for HABs. For drinking water utilities this could mean a reduction of operational expenses; for recreational areas this could mean having the time to treat a waterway and avoid a closure.

To be effective, HAB alarm systems need to fulfill four main criteria: 1) they need to be accurate enough to avoid false positives and negatives; 2) be low maintenance and require less labor than manual sampling; 3) they should provide remote actionable information on the waterway's status when it is appropriate; and 4) should have a low cost and installation tie.

However, the appropriate threshold for each of the above criteria differs from one application to the next and greatly impacts what monitoring method is most appropriate.

The authors will present:

- An overview of various HAB alarm system methodologies and an assessment of what application works best for each type.
- A summary of costs and maintenance requirements for typical HAB alarm systems.
- A description of new methods to automate remote hardware maintenance developed by the authors.
- Case studies at two locations with side-by-side comparisons of separate monitoring tools over several months.

The authors of this abstract have a financial interest in the product described.

General Session 2A: Alum 2

November 17, 2021

Using Aluminum Floculants to Treat Stormwater Ponds to Control Phosphorus in Verona, Wisconsin

Marten J. Cieslik[1] and Harvey Harper[2]
[1]Verona Public Works, Verona, Wisconsin; [2]Environmental Research & Design, Inc., Orlando, Florida

The Sugar River in Dane County, Wisconsin is on the impaired waters list due to phosphorus levels. The City of Verona is in the Sugar River Watershed. One stormwater pond was treated with ACH in the spring of 2019 with subsequent monthly monitoring. Phosphorus levels were significantly reduced. Verona expanded the stormwater pond monitoring program to 8 locations in 2020. The expanded monitoring showed high phosphorus levels in most of the ponds. During the spring of 2021 three storm water ponds were treated with Alum. The American Way pond which was treated in 2019 was retreated in 2021. Two smaller ponds were selected for treatment since they had recently had sediment removed and had high phosphorus levels. The purpose of the program is to determine the viability of using aluminum flocculants as a tool to reduce phosphorus levels in storm water. The conceptual model of the program, 2021 monitoring, plans for future testing and treatment, and lessons learned will be presented.

2 Tools Are Better Than 1: The Power of Combined Alum and Phoslock Addition to Improve Water Quality in Lakes and Reservoirs

Byran Fuhrmann[1], West Bishop[2], Scott Shular[3], and Mark Heilman[4]
[1]EutroPHIX, Whitakers, North Carolina; [2]SePRO, Whitakers, North Carolina; [3]EutroPHIX, Carmel, Indiana; [4]SePRO, Carmel, Indiana

Excessive phosphorus (P) levels in lakes and reservoirs is widely considered to be the primary driver of harmful algae blooms (HABs). HABs tend to be dominated by cyanobacteria, many of which are capable of producing cyanotoxins. Elevated cyanotoxins often result in the shutdown of recreational waterbodies and have led to public health crises such as in Toledo, Ohio where the drinking water conveyance system was shut down for more than 400,000 residents due to elevated cyanotoxins in the drinking water supply.

Sediment release of P is often a large contributor to the total P-loading, especially in water bodies that experience seasonal anoxia or sediment resuspension from mixing. Alum and Phoslock® are two popular methods which can be implemented to reduce sediment P-release and significantly reduce water column P concentrations. This presentation will provide a background on these two technologies and cover the pros and cons of each method of P-mitigation. This background will provide insight into why a combination of the two technologies may be synergistic from a cost-benefit and an ecological perspective. This presentation will also cover previous case studies where alum and Phoslock have been used in combination for substantial water quality improvements.

The authors of this abstract have a financial interest in Phoslock®, which is described in this presentation.

General Session 2B: Aquatic Plant Management

November 17, 2021

*Application of UAS to Track Invasive Growth of Floating Yellow Heart

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Floating Yellow Heart is an invasive species usually only found in east Asia; this made its first known appearance in America at Lake Carl Blackwell in Stillwater Oklahoma a surprise. Upon its discovery the plant had spread to several different coves and if left unchecked could choke out the natural ecology of the entire lake, affecting the water supply of Oklahoma State University. While this threat could be dealt with using targeted herbicides, because of its expansive spread, tracking the effectiveness of this treatment would be difficult. Oklahoma State University's Unmanned System Research Institute (USRI) was asked to find a solution using Unmanned Aerial Systems (UAS). This effort was a resounding success. Using a small flight team and off-the-shelf vehicles it was possible to survey the affected region in less than two hours and provide photogrammetric tools to quantitatively track the effectiveness of the treatment. Without this methodology each attempt at measuring the amount of floating yellow heart would have required a boat and an entire day to only obtain only qualitative estimations. The application of unmanned technology like this could improve the way that the health of water sources is evaluated by drastically improving precision and efficiency.

Evaluation of Monitoring and Delivery of Aquatic Herbicide Using Drones

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Use of unmanned aerial systems (UAS) have recently become mainstream due to the evolution of lightweight and low-cost components. These tools can be used for various applications including multispectral and RGB mapping and recently USRI started working with an herbicide company to explore product application on an invasive plant species. Lake Carl Blackwell in Stillwater, Oklahoma became infested with floating yellow heart, a harmful invasive lily that sits on the surface of the water. UAS were used to map the area as the floating yellow heart was treated with ProcellaCOR and the efficacy was tracked. Drone delivery is also utilized to reach application locations unreachable by boat.

Floating yellow heart is an invasive plant species that became prevalent in Lake Carl Blackwell, Oklahoma, a manmade reservoir that is a water supply for Oklahoma State University. The infestation rendered some areas of the lake inaccessible and choked off endemic plant species.

ProcellaCOR herbicide was administered to the infested areas manually via boat. Aerial surveys are used to monitor the spread over time and provides situational awareness to track the growth. Both multispectral and RGB cameras are used to monitor the die-off and determine the efficacy of the herbicide application.

The die-off was almost immediate, and the results are monitored via UAS. Aerial surveys detected a small resurgence in regions inaccessible by boat or ground due to growth. Future work will include monitoring the lake during the spring and summer months in 2020 and aerial application by UAS.

*The Ecology of Submersed Aquatic Vegetation Communities Under Management in Select Florida Lakes

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Submersed aquatic vegetation (SAV) is a major ecological component of Florida's shallow lake systems. Hydrilla (*Hydrilla verticillata* [L.F.] Royle) is a non-native SAV dominating many of these lakes and is often observed to be growing in large monotypic cultures exclusive to other native SAV community members. This invasive species is the number one priority for aquatic plant management in the state of Florida with desired outcomes to conserve native SAV diversity. We are studying the effects on SAV community ecology from selective hydrilla management activities. This investigation is being conducted in two mesotrophic systems, Lake Sampson (804 hectares) in Bradford County and Lake Mann (107 hectares) in Orange County. Surveys have been conducted before and after selective herbicide treatments that were administered in early spring of 2021. Data on species and abundance were recorded with point intercept, hydroacoustic, and airborne imagery surveys on monthly intervals offering community structure data with high spatial and temporal resolution. Here, we present on some of the basic attributes in community ecology consisting of native and nonnative patch networks along with local and lake-level diversity indices to describe patterns of environmental filtering and competitive exclusion. Furthermore, replacement series competition experiments were conducted in mesocosms between native and invasive species as a complement to the field trials. Selective hydrilla management should enhance local composition of native SAV communities.

General Session 2C: Novel Stressors

November 17, 2021

The Vulnerability of a Closed-Basin Lake to Runoff Pollution: A Lake Restoration Case Study

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Restorative Lake Sciences, Spring Lake, Michigan

Sherman Lake (N 42° 21.096, W 85° 23.119) is located in sections 29 and 32 of Ross Township, (T.1S, R.9W) in Kalamazoo County, Michigan. The surface area is approximately 168 acres, and the lake is of glacial origin with no inlet or outlet. Sherman Lake has a maximum depth of 35 feet and a mean depth of approximately 15.2 feet. The total lake volume of the lake is estimated to be approximately 2,554 acre-feet and the estimated hydraulic retention time of Sherman Lake is approximately 3.6 years which makes the lake vulnerable to drain pollutant inputs. Sherman Lake has a lake perimeter of approximately 3.1 miles.

A review of water quality data over the past decade indicates that the mean annual phosphorus concentrations are significantly increasing ($p < .05$), and the lake clarity is significantly decreasing ($p < .05$). In 2015, it was a series of drains around the lake contributed a large quantity of nutrient and suspended solid inputs to the lake during heavy rain events and are continually creating issues with water quality. A whole-lake laminar flow aeration system was installed in the lake in 2013 and there have been improvements with soft bottom consolidation as well as the significant reduction of nuisance algae and increases in water column dissolved oxygen. However, additional improvements are being compromised by these drain inputs which emphasizes the vulnerability of small closed-basin lakes to runoff.

Balancing Needs, Wants and Changing Climate – Tales of Lake De-icers and Their Potential Effects on Lake Ecology and Recreation

Kiyoko Yokota, Sierra Stickney, and Paul H. Lord
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Dock de-icers are devices that prevent ice formation around docks and shorelines of lakes via forced circulation or bubbling of water. While banned in some US states, the use of such devices is not regulated in other states including New York State. Various concerns and conflicts related to dock de-icers have been voiced in New York State, including installation of oversized systems, sediment re-suspension, alteration of the lake heat budget, biogeochemistry, food web, and access and safety for recreational activities on frozen lakes. While hydrological models can simulate the effect of lake-wide ice and snow cover loss on lake water temperature under hypothetical scenarios, observed data on how dock de-icers locally affect water column temperature are scarce. We collected pilot data around a forced-circulation de-icer on Otsego Lake, New York, which provided evidence that proximity to the device exacerbated the cooling effects of cold snaps during winter.

*Arsenic Levels in Private Wells Within Becker County, Minnesota

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In Minnesota, approximately 1.2 million people get their drinking water from a private well. The Safe Drinking Water limit for arsenic in drinking water is 10 ppb. Arsenic in drinking water is an issue in Minnesota. The Minnesota Department of Health (MDH) has required arsenic to be measured in all new wells since 2008. Well drillers are responsible for submission of arsenic data to the MDH, as well as the notification of the owners. Becker County is located in Northwestern Minnesota, an area that typically experiences higher levels of arsenic in well water, due to glacial deposits. Arsenic well data for Becker County was obtained through Emily Berquist (MDH) and analyzed for trends. This county has 1,891 private wells, and 27.5% (520 wells) were above the safe drinking water limit. The highest arsenic level was 96 ppb. There is no correlation observed between arsenic concentrations and drill depth; however, the top four arsenic concentrations were found in private wells clustering near large bodies of water. Though this may be coincidental, it is worth noting. Becker County has been proactive, offering free annual well water testing clinics since 1995. The Becker Soil & Water Conservation District sponsors water testing clinics at the Becker County Fair, as well.

General Session 3A: Invasive Species

November 18, 2021

Keeping Invasive Q/Z Mussels Out of the America's Favorite Bass Fishing Lake, Clear Lake, California, USA

Angela De Palma-Dow
County of Lake Water Resources, Lakeport, California

Clear Lake (Lake County, California) is the largest natural freshwater lake located entirely within California and is extremely susceptible to an invasive Quagga & Zebra (Q/Z) mussel invasion. Clear Lake is open and accessible year-around at any of its 400+ public and private ramps and the water temperature, calcium, pH, and salinity are well within the preferred ranges for Q/Z mussel introduction and establishment. The shallow, calm, and productive waters along the littoral zone attracts water users and fishermen from all over the country. In 2020, Clear Lake was voted the #1 USA Bass fishing lake of the decade (Bassmaster) and now holds the state record for both the largest White and Black Crappie. The current Q/Z prevention program is supported by federal, state, city and tribal partners and has widespread buy-in from local businesses and the public. Based on substrate and tow monitoring data, we have so far been successful in preventing QZ introductions. This talk will present how this program is executed and sustained, how it has been impacted by the COVID-19 pandemic, and how managers plan to enhance the program using digital technology and improved education and outreach so that Clear Lake maintains mussel-free.

Meet Them Where They're at: An Industry Approach to AIS Prevention

Brant Dupree[1] and Kate Wilson[2]
[1]Big Sky Watershed Member, Missoula, Montana; [2]Montana Department of Natural Resources, Missoula, Montana

The Upper Columbia Conservation Commission (UC3) was formed by the Montana State Legislature in 2017, after the detection of invasive Dreissenid mussel veligers in Montana. UC3 was established to foster close cooperation and coordination between all parties to stop the further spread of aquatic invasive species (AIS). Since 2019, UC3 has hosted an AmeriCorps member to implement an AIS Industry Outreach Project in the basin, meeting with the more than 120 industry partners in various water-based businesses to discuss AIS in Montana and build relationships with industry partners. At the end of these visits, we utilize Community-Based Social Marketing methodology by asking stakeholders to make a commitment and become a 'Clean, Drain, Dry Partner', in which they are provided AIS materials to disseminate to their customers and staff as well as a 'Clean, Drain, Dry Partner' sign to recognize them for their service. We also feature them in social media to acknowledge and encourage their commitment. Metrics and information are collected at each visit/interaction to inform and evaluate the efficacy of the program moving forward.

The results of these visits are generally positive and incredibly informative. Industry partners are invested in preventing the spread of AIS as these waters are the source of their livelihoods. By building industry partners, we can build a key line of defense against AIS by bridging the gap of knowledge between agency officials/policy makers and industry partners, business owners, and their customers.

Baited Box Netting as an Effective and Efficient Way to Selectively Remove Invasive Common Carp

M. Vincent Hirt[1], Peter J. Hundt[2], Cameron Swanson[1], Jenna Barlow[1], and Przemek Bajer[2,1]
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Common Carp (*Cyprinus carpio*) is a widespread, destructive, invasive fish species for which effective management strategies are needed to reduce population densities to improve water quality and restore habitat for native species. We have developed an integrated technology (*i.e.*, 'box nets') that uses bait (cracked corn) to attract carp to specific sites, monitors the numbers of carp at the bait remotely to determine peak feeding periods, and can also be activated remotely to capture the carp. These techniques were tested in four Minnesota lakes ranging in size from as small as eight hectares to over 85 hectares with population sizes ranging from about 1,000 to over 34,000 carp. As few as two box nets and no more than six were deployed in each lake. Between two and seven baiting-removal cycles were conducted in each lake. Using mark and recapture methods and length/weight regressions we were able to estimate pre- and post-removal population sizes and biomass densities and evaluate the effectiveness of box netting. Individual net could yield as many as 1,800 carp in a single removal event and in general, box netting, even with such low effort, was effective at removing over 40% of the carp population and over 44% of the carp biomass density in some cases. Overall, we found that baiting with cracked corn creates predictable and reliable carp aggregations and these aggregations can be trapped and removed with box nets with nearly zero bycatch.

The authors of this abstract have a financial interest in the corporation, commercial product, methods, and trade name described.

Apparent Eradication of Zebra Mussels (*Dreissena polymorpha*) From an Entire Lake Using Low Doses of EarthTec QZ Ionic Copper

David Hammond[1], James Bland[2], and Shelby Johnson[3]
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In the 35 years since zebra and quagga mussels were introduced to North America, conventional wisdom has held that once they infest a water body nothing can be done to remove them. However, in 2017 a liquid ionic copper called EarthTec QZ was used to successfully eradicate quagga mussels from a 30-acre lake in Pennsylvania, with no measurable long-term impacts on non-target species. Total product applied to accomplish the 2017 eradication amounted to 0.44 mg/L as elemental copper, which was remarkable because previous attempts to control mussels had used rates exceeding 1.0 mg/L. Then, in 2019 zebra mussels were discovered in a 30-acre lake north of Chicago, called Valley Lo Lake. By the time of their discovery the mussels were well established, occurring at high densities on boats and rocks around the shoreline. In summer of 2021, EarthTec QZ was applied to Valley Lo Lake with the objective to eradicate zebra mussels from the entire lake. Cages containing live adults were used to monitor and estimate mortality. The initial treatment protocol contemplated up to 4 dosing events, but 10 days after the first dose of 0.24 mg/L copper had been applied around the shoreline of the lake, the mortality of adult mussels in cages had already reached 100% and we were unable to find a single live zebra mussel anywhere in the lake, so no additional product was applied. While it is virtually impossible to prove the absence of any survivors (ongoing monitoring in future years will be needed to confirm), it appears the eradication is complete, without major collateral impacts on non-target organisms. The prospect of eradicating zebra mussels from an entire lake with a single dose of just 0.24 mg/L as copper is an exciting development. Factors affecting the project's outcome and effects on non-targets will be discussed.

The authors of this abstract have a financial interest in the product described in this presentation.

General Session 3B: Paleolimnology

November 18, 2021

*Developing Diatom-Based Paleolimnological Tools to Assessing Possible Lake Ecosystem Recovery From Acidification in a Suite of Lakes From Sudbury, Ontario, Canada

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Lakes in the Sudbury region (Ontario, Canada) have been heavily impacted by mining and smelting activities since the late 20th century, resulting in pronounced acidification and metal contamination. Regulations on restricting smelting emissions were enacted five decades ago, and a certain degree of chemical recovery (*i.e.*, increasing pH and decreasing metal concentrations) occurred in many lakes. The biological recovery of these lakes, however, may lag behind the chemical recovery, or may never be achieved due to newly emerging environmental stressors (*e.g.*, climate warming). In this study, we assess the most recent biological recovery status of lakes in the Sudbury region (n = 80) using fossil diatoms as the primary bioindicator. Canonical correspondence analysis (CCA) is used to assess the relationships between diatom species composition and environmental variables. Lakewater pH was identified as the strongest environmental variable influencing the diatom assemblage composition, while total phosphorus (TP), conductivity, and metal concentrations (nickel and copper) explained lesser amounts of diatom assemblage variability. Different regression and calibration methods were used to build a pH inference model, with weighted-averaging model (classical deshrinking) showing the best statistical performance (R^2_{boot} = 0.783; RMSEP = 0.246). Additionally, by comparing the modern diatom assemblages with pre-impact assemblages, as well as from earlier diatom-based studies, we propose to explore the degree of biological recovery that has occurred in these 80 lakes.

Paleolimnology of Possum Kingdom Lake, Texas

Lane Allen and Victoria Chraibi
Tarleton State University, Stephenville, Texas

Harmful algal blooms (HAB) are increasingly reported in Texas reservoirs, but it is unclear how long this trend has been developing in water bodies less than 150 years old. This study retrieved sediment cores from Possum Kingdom Lake on the Brazos River, which has had recent HAB events of both cyanobacteria and *Prymnesium parvum* including a fish kill in 2020. Sediment geochemistry and fossil algae were characterized to reconstruct the environmental history of a river developing into a lake after dam construction to consider potential drivers of HAB events. Post-impoundment conditions were characterized by high detrital input and low primary productivity, likely due to erosion inputs from the construction of the dam. Eventually the phytoplankton community established and was dominated by soft algae based upon Ca:Ti inferred primary productivity. The green alga *Phacotus* was initially common, indicating eutrophic conditions. Recently the diatom community has significantly shifted to be dominated by *Cyclotella atomus*, a small planktic species associated with warmer, longer summers. The core sediment also displays evidence of severe droughts such as that of 2011–2014. Recent *Prymnesium parvum* blooms occurred during the *Cyclotella atomus* dominated period, so the trends documented in the sediment record may provide insight into the environmental factors driving this type of HAB event.

General Session 3C: Theory and Application

November 18, 2021

Applying Innate Wisdom to Our Work

Diane Lynch
Lynch Associates, Elk River, Minnesota

We were born with innate guidance—call it intuition, a moral compass, conscience or inner knowing. When we were young, we relied upon that innate guidance to help us survive. As we grew older, we subverted those natural instincts due to pressures by enculturation, academics, and science. Accelerating impacts from climate change demand that we embrace a new way of thinking and acting—a new paradigm. How can we reconnect ourselves with those innate abilities and use them to help make time-sensitive and critical decisions about what is needed at this time of environmental crisis?

We will explore the energy nature of the body and demonstrate how to use meditation, mindfulness, breathing techniques and other practices to help us connect with that deeper knowledge and how to apply that wisdom in our daily work as water resources professionals.

The author of this abstract has a financial interest in the commercial product described.

Indigenous Wisdom's Lessons for Science

Diane Lynch
Lynch Associates, Elk River, Minnesota

Accelerating impacts from climate change demand that we embrace a new way of thinking and acting – a new paradigm. For thousands of years, indigenous communities have been caretakers of the Earth and understand deeply the symbiotic relationship between humans and the earth. It is estimated that while Indigenous peoples comprise only about 6% of the population, they protect about 80% of biodiversity left in the world. What can we learn from indigenous peoples to guide us with wisdom to help make time-sensitive and critical decisions about what is needed at this time of environmental crisis?

We will review several fundamental earthcentric beliefs and practices of three tribal communities in North America and the lessons we can learn that will inspire building blocks for a new paradigm and that we can apply in our daily work as water resources professionals."

Wetland Habitat Restoration and Remediation and Shoreline Restoration at a Large, Private RV Resort in Upstate New York, USA

Michael R. Martin
Cedarwood Engineering Services, PLLC, Warresnburg, New York

A comprehensive restoration of wetland habitat and riverbank shoreline under Adirondack Park Agency and US Army Corps of Engineers consent orders was conducted at a large recreational vehicle camping resort near Lake George, New York. The $1.3M wetland restoration & remediation and shoreline restoration project included culvert replacement with open bottom arched box culverts, the restoration and creation of over 5 acres of wetlands and shoreline restoration of 350+ feet of the Schroon River using root wads. As a result of the project, river access has been improved and aquatic organism passage has been enhanced between the Schroon River and associated tributaries and riparian wetlands. Michael R. Martin, NALMS Certified Lake Manager, Environmental Scientist for Cedarwood Engineering and project manager for the project, will make a presentation of the work, including before, during and after photographs.

Resurrecting Clean Lakes Funding for US Lakes

NALMS 314 Working Group

Section 314 of the US Clean Water Act has not been funded by Congress for the last 25 years. There were some key features of this program that make it a good model for addressing the nation's lakes in crisis now. It had a mechanism to fund basic lake trend and status monitoring, the underpinning of good lake management. It then funded diagnostic studies on lakes where trends or status were not meeting standards. It then funded interventions that were based on findings from the diagnostic studies. Finally, it funded follow up monitoring to determine if the intervention succeeded. Today, across the country there is a growing pressure being put on elected officials to do something about the deteriorating lake water quality on highly valued lakes. Meanwhile, there is the environmental justice issue surrounding polluted urban lakes. Climate change is exacerbating these issues. Politicians are diverting taxpayer money to interventions in lakes that do not have sufficient monitoring or that have not had adequate diagnostic study to determine the cause of the poor or deteriorating water quality. Few of these interventions have follow up monitoring to determine if they can be used as a model for other lake systems. As of 2017, only 10% of the nation's lakes remain oligotrophic. Implementation of the maintain and protect goals need resources too. It is time to resurrect the 314 funding and tailor it to the needs of the nation's lakes in 2021 and beyond.