Presentation Abstracts

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Interactive Sessions

Interactive Session A1: National Lakes Assessment

November 17, 2020 | 13:30 – 15:00

Development of Ambient Sediment Quality Values for the 2017 National Lakes Assessment (NLA) Study

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For the first time, surficial bed sediment contaminants and ancillary parameters were analyzed as part of the 2017 National Lakes Assessment study. To explore the data further, ambient background threshold values were calculated at regional and statewide scales. These analyses focused on unweighted parameters with < 80% nondetects, including 16 metal(loid)s, 25 polycyclic aromatic hydrocarbons (PAHs), total organic carbon, and grain size fractions. Data from 969 lake sites across the contiguous US were divided into their respective US EPA regions to provide a practical separation for use by states, tribes, and others. Additionally, data for two ecoregions bisecting Minnesota were parsed into the Temperate Plains and Upper Midwest categories to provide examples of using ecoregion scales. Lastly, the data for Minnesota were used as a case study. For each scenario, ambient background threshold values were calculated for the 95% upper tolerance limit with 95% coverage (*i.e.*, UTL95-95). The UTL95-95 represents the value below which 95% of the population values are expected to fall with 95% confidence. For censored (*i.e.*, nondetect) data, the Kaplan-Meier versions of the UTL95-95 calculations were performed. These values can be used as benchmarks to compare to surficial sediment quality data collected from independent studies within similar geographic areas. Exceedances of the UTL95-95 values can be indicative of natural geologic and/or anthropogenic influences on the surrounding watersheds. These results can also be used to help prioritize state agency and tribal activities related to ambient sediment quality, as well as for future status and trends assessments.

National Framework for Ranking Lakes by Potential for Anthropogenic Hydro-Alteration

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Lake hydrology faces multiple stressors from human activity. Land use (*e.g.*, irrigated agriculture) and dams can alter lake inflows and outflows beyond natural ranges and changing climate conditions may exacerbate these disturbances. Broad-scale hydrologic disturbance measures are needed to assess human impacts on lake hydrology at regional and national extents. We developed a framework to rank lakes by the potential for anthropogenic alteration of lake hydrology (HydrAP) caused by dams and land use activities using national-scale datasets. We ranked lakes in the US EPA National Lakes Assessment (NLA) on a scale from zero to seven, spanning lakes with no apparent human hydrologic disturbances to lakes with large dams and/or intensive land use with potential to alter water levels. We inferred population HydrAP distributions in the conterminous US (CONUS) using the NLA probabilistic weights. About half of CONUS lakes were estimated to have moderate to high hydro-alteration potential (HydrAP ranks 3–7) and the other half had no to minimal hydro-alteration potential (HydrAP ranks 0–2). Water residence time (τ) and lake water-level change were associated with HydrAP ranks and support the framework's ability to identify human infrastructure and activities that can alter lake hydrology. Lake τ were shorter in high HydrAP-ranked lakes. However, water-level change and HydrAP relationships varied by ecoregion and likely reflect different regional water management strategies that can promote or suppress large water-level fluctuations. The HydrAP framework is a robust tool to estimate human hydrologic disturbances and offers promise to support large-scale lake hydrologic assessments.

The US EPA's National Lakes Assessment: Fundamentals, Survey Highlights and Future Planning

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The National Lakes Assessment (NLA) is conducted in collaboration with states, tribes, other federal agencies and partners every five years as a component of the US EPA National Aquatic Resource Surveys (NARS). The surveys sample and estimate the condition of the Nation's different water body types on a rotating basis. Standardized protocols and select core indicators are used to develop statistically valid assessments of the biological and recreational condition of US waters at the national and regional scale and are designed to assess change in condition over time. The NARS program also provides opportunities to explore research indicators that advance our understanding of the waterbody type. As a nationwide collaborative survey, the NLA offers a unique opportunity to frame discussions and plan strategies for the protection and restoration of lakes across the United States. Results of the NLA also provide a broad range of information that can help us better understand the condition of lakes in the United States, some of the stressors affecting them, and how stressors relate to local conditions. This presentation will provide an overview of NLA fundamentals including the survey design, target population, and the core indicators; highlights from NLA 2007, 2012, and 2017; how to explore and access NLA data; and planning for the upcoming 2022 survey.

USEPA's National Lakes Assessment Sediment Study

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Surficial bed sediments were collected and analyzed for contaminants and physical parameters as part of the 2017 National Lakes Assessment (NLA). The NLA is conducted every five years as a component of the US EPA's National Aquatic Resource Surveys. The NLA is a probability-based survey of the nation's lakes and reservoirs distributed across six size classes and nine aggregated Omernik Level 3 ecoregions. State and tribal partners collected core samples of the upper 5 cm of sediment from the deepest part of lakes, and the midpoint of reservoirs, during the summer index period. A subset of lakes were revisited to assess site variability. The sediment samples were analyzed for metal(loid)s, PAHs, PCB congeners, legacy pesticides, grain size and total organic carbon. To interpret the data, R code was developed to compile, analyze, and visualize the results. Mean probable effect concentration quotients (PEC-Qs) were calculated to distill data from a mixture of metal(loid)s and total PAHs into one unitless index. These values were used to categorize lake sediment quality as good, fair, or poor. Data were also compared to consensus-based sediment quality guidelines and assessed to evaluate ecoregional differences in individual contaminants. In this presentation we will discuss the different analyses that were completed to review the data and show example results based on ecoregion and national evaluations of the data. This study presents the first national assessment of lake sediment contaminant concentrations and provides a baseline for future status and trends monitoring and assessment.

Interactive Session A2: Remote Sensing

November 17, 2020 | 13:30 – 15:00

Satellite Remote Sensing in Support of Lake Management

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Lakes provide us with a number of environmental and economic benefits, as well as contribute to our quality of life. Timely and effective water quality monitoring is critical to proper lake management and anticipating and mitigating water quality issues. Budgetary cuts and staffing shortages have exacerbated efforts to effectively monitor our lakes. AquaWatch (https://www.geoaquawatch.org) is a global organization of water quality experts who are building the capacity and use of satellites to derive water quality information from space, thereby providing an additional tool for lake managers and the public to monitor water quality conditions of their lake. AquaWatch is currently constructing a "knowledge hub" to help empower organizations and professionals of the water quality community with the relevant resources. This effort will utilize *in situ* data, modeling, and satellite technology to monitor and manage these precious resources.

Spatial and Temporal Trend Analysis of Water Quality Using Satellite Imagery for 10,000+ Minnesota Lakes

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Using satellite imagery, we have been assessing lake water quality in Minnesota, USA for over 20 years. 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 often. Using these new capabilities we created a 35-year (1985–2020) satellite-derived water clarity database and 2015 and 2016 CDOM maps for 10,000+ lakes. These maps along with auxiliary data were used for spatial and temporal trend analyses to explain regional differences in water quality. Areas dominated by forest/wetland had higher water clarity than agricultural/developed areas. Decreases in water clarity throughout the state were attributed to land use intensification and increasing late summer temperatures. Differences in CDOM were related to predominant land cover/use with wetland/forested area associated with higher CDOM than agricultural areas. CDOM temporal changes were attributed to wetter conditions in 2016: decreases in agricultural areas due to dilution by rainfall and increases in forest/wetlands areas, due to enhanced CDOM transport from forest/wetlands.

#Using Citizen Science and Satellite Imagery to Monitor Lake Water Storage

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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. Real-time, automated monitoring of even a small 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 1200 citizen scientists in monitoring lake levels. We combine this data with lake surface area measurements, calculated using Landsat 8 and Sentinel 2 satellite imagery, to understand how the quantity of water stored in lakes changes over time. We also compared measurements provided by citizen scientists with pressure transducer data and found that citizen scientists provide accurate lake level data, with a mean absolute error of 1.6 cm.

LOCSS is studying more than sixty lakes in five US states, France, and Bangladesh. We determined the correlation of lake volume changes between lake pairs within these regions. These pairs are, on average, significantly correlated (Spearman's r~0.5), though many pairs remain uncorrelated. In some regions (but not others) we found that distance between lakes predicts correlation. These results suggest that both local and regional factors are influencing variations in lake water storage.

We will also discuss the future expansion of the LOCSS network and plans to use its data to evaluate measurements from NASA's forthcoming Surface Water and Ocean Topography satellite.

*Multi-Decadal Improvements in US Lake Clarity

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Recent work examining the state of freshwater resources across the globe paints an increasingly dire picture of degraded water quality. However, much of this previous work focuses on a small subset of large waterbodies that is unrepresentative of the overall freshwater landscape. Here, we use 35 years of Landsat imagery (1984–2018) to generate time series of summertime lake water clarity for a representative sample of over 13,000 US lakes. We aggregate these time series at the ecoregion scale and estimate trends in clarity over the past 35 years. Results show an increase in water clarity across at least 7 of the 9 ecoregions, with the largest increases (> 0.8 cm yr^{-1}) in the Xeric West and Northern Appalachians. These increases in clarity are concentrated in lakes smaller than 10 km^2 and those near urban areas that have seen the highest reductions in point source pollution due to the Clean Water Act. Specifically, lakes under 10 km^2 show a median increase of 0.27 cm yr^{-1} compared to 0.08 cm yr^{-1} for lakes larger than 10 km^2, and lakes in catchments with high population densities show average increases four times higher than those in low population areas. The observed patterns suggest that local and federal management efforts have decreased nutrient and sediment loading to freshwater resources over the study period, with greater impacts in smaller waterbodies due to their higher responsiveness to watershed-scale biogeophysical changes.

Interactive Session B1: NALMS at 40 – 40 Years of Lake Management

November 17, 2020 | 15:30 – 17:00

Forty Years of NALMS and Lake Management: What Have We Learned?

Kenneth J. Wagner
WRS, Wilbraham, Massachusetts

As we celebrate 40 years of NALMS it is appropriate to consider the advancements reported at NALMS symposia and our journal. What we have learned includes:

1. Lakes can be protected or rehabilitated but are rarely restored; once perturbed, a complete return to previous conditions is unlikely and we manage for desired conditions that support uses.

2. There are limits to watershed alteration, beyond which damage to downstream lakes appears unavoidable.

3. There are limits to what BMPs can do to protect lakes; there is currently no way to make highly urbanized or agricultural land behave as though it was the natural land from which it was created.

4. Watershed management can protect a lake but is rarely adequate to rehabilitate a damaged lake; in-lake actions are necessary to address legacy loading or invasive species.

5. Dredging, oxygenation and/or P inactivation are the only proven methodologies for addressing legacy P loads; great advancement has been made in the application of oxygenation and P inactivation over the last four decades. However, additional techniques remain under development and should not be disregarded.

6. It is extremely difficult to eradicate an invasive species once it has become established; prevention and rapid response are therefore critical to lake management.

7. Lake management has three key components: science, economics and institutions. While the science can be improved and economics will impose constraints, institutions are routinely the weakest link in the process.

8. We need to keep learning; lake management is not yet a mature discipline.

Paleolimnological Studies Support Lake Management in Florida USA: A 40-Year Retrospective, With Methods and Objectives for the Future

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NALMS was founded 40 years ago, and this year marks 40 years of our applied paleolimnological research in Florida. This presentation reviews paleolimnological studies we performed to support evidence-based lake-management decisions by Florida's regional Water Management Districts, and by state, county, and municipal agencies. Our research began under Edward S. Deevey, Jr. and focused on developing methods to quantify limnological changes, particularly eutrophication, that arose from watershed disturbances. These methods proved useful for defining appropriate goals for lake-restoration programs. We examined changes that arose from increased nutrient loading, groundwater augmentation, alkalization from ion and nutrient loading, and contamination by aresenical herbicides. We studied the onset and ecological effects of cyanobacterial proliferation, and the use of mass-balance methods for defining critical nutrient-loading thresholds. We've used stable isotopes to evaluate nitrogen and carbon sources, and to document changes in productivity and macrophyte communities. Recent work documented the effects of engineered hydrological changes on lake processes. Florida's ~8000 lakes are naturally diverse, so no single nutrient-criteria standard is appropriate for all lakes. Our studies led to incorporation of paleolimnological evidence into state statutes for defining nutrient-criteria standards. We conducted a purpose-designed study to help resolve a 2008 federal lawsuit of the US EPA related to nutrient criteria for Florida lakes, and helped resolve a 2012 federal lawsuit about the historical presence of cyanobacteria. We discuss new methods and recent findings relevant to management, and the future roles of paleolimnology for holistically assessing changes, and for supporting the restoration and conservation of lakes.

#Effects of Climate Change and Land Use on New York Lakes

Monica Matt, David Matthews, Susan O'Donnell, David O'Donnell, David Andrews, and MaryGail Perkins
Upstate Freshwater Institute, Syracuse, New York

In an age of climate change and accelerated urban development, the quality and nature of our freshwater resources are changing in response to these alterations. Using data collected through the New York Citizens Statewide Lake Assessment Program (a collaborative effort between the New York State Federation of Lake Associations and New York State Department of Environmental Conservation) and the Upstate Freshwater Institute, we analyzed historical trends in water quality and characteristics of lakes across the state in relation to climate change and altered land use. We can learn a lot through these historical analyses, but even more importantly, we can use this information to guide future lake and watershed management decisions. Watershed and lake models (GWLF-E and CE-QUAL-W2) will be applied to selected systems to evaluate potential future changes in water quality caused by climate change and altered land use. Modeling will focus on potential impacts to thermal characteristics and increased prevalence of cyanobacteria.

Interactive Session B2: Paleolimnology

November 17, 2020 | 15:30 – 17:00

*Monitoring and Paleolimnology Suggest Site-Specific Nutrient Standard Needed for the Red Lake Nation and Minnesota's Largest Lake

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The challenges of lake management increase when lakes are subjected to development, climate change, aquatic invasive species, and nutrient enrichment. Targeted monitoring strategies make assessing the ecosystem health of lakes easier. Strategies can include historical knowledge, reference conditions, models, and assessing downstream effects. In Minnesota, when lakes exceed state water quality standards, remediation plans are implemented, or the body of water can be assessed for a site-specific standard. Upper Red Lake and Lower Red Lake, managed by the Red Lake Nation and Minnesota, experience extensive cyanobacterial blooms as well as routinely exceed regional nutrient criteria for total phosphorus and chlorophyll *a*. The last 20 years of water quality monitoring data show a stable recent history with no significant trends. Historical accounts and paleolimnological evidence were used to investigate the lakes' longer limnological history to determine whether recent lake conditions are degraded or if a site-specific nutrient standard should be recommended. Biogeochemical evidence (sedimentation, phosphorus fractionation, biogenic silica, diatom community analysis, and algae pigment data) from ten sediment cores revealed complex dynamics within these large shallow basins and a subtle increase in productivity over the last 200 years. While a subtle productivity increase was observed, diatom-inferred phosphorus showed no significant changes in the sediment cores and predicted historical total phosphorus values within the range of modern measured values. Evidence indicates the modern condition is not degraded compared to historical conditions, and we recommend a site-specific nutrient standard for these two unique large shallow lakes.

*Investigating Diatom Responses to Anthropogenic Stressors Across Canada's Highly Populated Mixedwood Plain Ecozone

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Lakes worldwide have been under the growing influence of multiple environmental stressors. To assess the effects of these stressors, paleolimnology is often used as an effective approach to reconstruct long-term ecological and environmental changes. In this study, we explored limnological changes in 27 lakes located in the most populated ecozone in Canada, the Mixedwood Plains, where we compared pre-industrial and contemporary conditions using diatoms. Additionally, we conducted a full sediment core analysis for Lac des Chicots as a case study, aiming to disentangle the effects of natural versus anthropogenic interactions, and to assess their relative effects on the lake's biotic structure. Our ordination analyses of the diatom assemblages indicated that lakes in the Mixedwood Plains have shifted in different directions with varying magnitudes over the past ~150 years. Lakes with more extensive human impacts in their watershed had higher Bray-Curtis dissimilarity values between modern and pre-industrial diatom assemblages (p = 0.0587), indicating greater compositional turnover than lakes under lower human impacts. The case study of Lac des Chicots tracks its dynamic history, revealing influences from both historical geological events and recent human activities. The modern diatom assemblage is dominated by mesotrophic and eutrophic planktonic taxa as well as small centric taxa, suggesting increased nutrients and a stronger and longer stratified period. Our study demonstrates that lakes in the Mixedwood Plains ecozone have experienced varied ecological changes associated with human impacts, highlighting the importance of reducing anthropogenic nutrient inputs and mitigating climate change to protect our lake ecosystems.

*Impacts of Asbestos Mine Tailings on the Sedimentological Evolution of a Chain of Lakes in the Thetford Mines Region (Southern Quebec, Canada)

Olivier Jacques and Reinhard Pienitz

Département de géographie, Université Laval, Québec, Canada

More than a century of asbestos mining activities in the Thetford Mines region resulted in the accumulation of gigantic tailings on the banks of the Bécancour River. The river widens downstream to form a chain of ponds and lakes (Stater, à la Truite, William, Joseph). The repercussions of the mine tailings on these aquatic ecosystems have been debated for decades. Some have claimed that they cause high sediment loads, others pretended that tailing erosion should be minimal. Here, we present the results of an extensive paleolimnological investigation that provides insight into changes in sedimentation dynamics over time. Sediment cores were collected from the 4 sites located downstream from the tailings and from a reference lake (Bécancour) located upstream. Radiometric ^{210}Pb dating revealed extreme increases in the sedimentation rates in Stater Pond as well as in lakes à la Truite, William and Joseph since 1960, when major hydrological changes resulted in high mining residue inputs to these water bodies. Loss-on-ignition and ICP-MS/ICP-AES analyses indicated that post-1960 sediments were highly enriched in mineral matter and metals abundantly present in the tailings. In contrast, the recent sediments of lake Bécancour were rich in organic matter and showed less pronounced sedimentological changes associated with the post-1960 period. Our results leave no doubt that massive amounts of tailing materials are transported to downstream sites, thereby threatening their sustainability. Our study highlights the usefulness of paleolimnology in providing crucial data for lake management decisions.

*Fur Farming, Climate Change, and Acidification Have Jointly Impacted Water Quality in Southwest Nova Scotian Lakes

Nell Libera and John P Smol

Paleoecological Environmental Assessment and Research Lab (PEARL), Department of Biology, Queen's University, Kingston, Ontario

Recent cyanobacterial blooms in southwest Nova Scotian lakes have prompted concerns from local residents and environmental organizations that these blooms may be linked to effluent from mink fur farms. The high volumes of phosphorus-rich wastes produced by this industry remained largely unregulated until 2013, despite a ~400% increase in pelt production since the 1980s. Monitoring data indicate hypereutrophic conditions in headwater lakes with fur farms in their catchment, and eutrophic conditions in downstream lakes. However, freshwater quality in this region may also be impacted by other stressors, including site-specific catchment land use, climate change, and the legacy effects of acidification. Here, we present paleolimnological data that examines long-term trends in eutrophication-related proxy data. This extends the limited monitoring window back in time to pre-date establishment of the region's mink farms. We used diatom assemblages in dated sediment cores from strategically selected lakes to reconstruct past pH, total phosphorus and water column stability. We also used spectrally-inferred chlorophyll *a* to compare trophic histories, and stable isotopes of N to trace inputs of farm wastes. Our preliminary data show coherent trends indicative of eutrophication which co-occur with fur farming production and a warming climate, providing evidence that fur farming has impacted water quality for decades. These records provide important insights for watershed management and help to determine restoration targets.

Interactive Session C1: Chemical (Nutrient) Management

November 18, 2020 | 12:00 – 13:30

A Holistic Adaptive Management Plan for Improving Como Lake Over the Next 20 Years

Britta Belden and Bob Fossum
Capitol Region Watershed District, St. Paul, Minnesota

Como Lake is a beloved natural resource in St. Paul, Minnesota that has been highly impacted over time by urban development as evidenced by frequent algal blooms and a curly-leaf pondweed infestation. Como Lake has been listed as impaired for nutrients since 2002 with annual average phosphorus concentrations measuring three-times greater than the State standard (60 μg/L). Excess phosphorus is due to decades of stormwater runoff as well as significant internal loading. Capitol Region Watershed District (CRWD) and its partners updated the Como Lake Management Plan (CLMP) in 2019 to define goals and management actions to improve water quality over the next 20 years. The CLMP takes a holistic approach to addressing water quality issues by identifying actions that work toward the goals of the plan under three categories: in-lake, watershed, and community actions. The identified actions are organized into a short-term implementation plan that operates on a 3-year adaptive management cycle. Actions from the short-term implementation plan will be completed and the lake's response will be evaluated. Based on how the lake responds, actions will be planned for the following 3-years to continue working toward water quality goals. This adaptive management strategy acknowledges that Como Lake is a living natural system and is designed to work with the lake as it changes.

In 2020, CRWD began implementing several management actions for the first implementation cycle including two projects: an herbicide application and an alum treatment. Monitoring will determine the effectiveness of these actions and help plan for future management.

Factors Controlling Phosphorus Solubility and Speciation in Aquatic Environments

Bryan Fuhrmann[1], Mark Heilman[2], West Bishop[3], Ryan Van Goethem[4], Scott Shuler[2], and Marc Beutel[5]
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Water column phosphorus, especially in the form of dissolved phosphate, is often the primary cause of the development of eutrophic conditions and associated harmful algal blooms in lakes and reservoirs. Phosphorus can accumulate in water bodies due to external sources, such as nutrient rich agricultural or storm water runoff or internal release from the sediment. Sediment phosphorus release can occur for many years following the reduction of external inputs so there is a great deal of interest in approaches to enhance sediment phosphorus retention. These strategies generally fall into two categories, redox management and geochemical sequestration. This talk will cover case studies of redox management strategies including aeration, oxygenation and nitrate addition. Geochemical sequestration strategies and case studies discussed include lanthanum modified bentonite (LMB), aluminum salts, and iron addition. Sediment phosphorus speciation is controlled by many factors which will be discussed in detail, including but not limited to pH, redox, organic matter, alkalinity, mineral composition, and calcium, iron, and aluminum content. Aeration and oxygenation have utility in some systems but can also disturb sediment which can mix nutrients into the water column. Nitrate addition generally reduced phosphorus release but is not appropriate for many lakes and reservoirs. Iron addition may hold promise in shallow lakes and reservoirs with sufficient dissolved oxygen but is subject to redox release. Aluminum salts may be effective in certain conditions but are generally sensitive to pH. LMB appears to hold promise in a variety of environmental conditions depending on management objectives.

Financial Interest Disclosure: The authors of this abstract has/have a financial interest in the general subject presented since the employer of some of the authors supports commercial products that contain one or more of the described technologies.

Water Quality, Sediment, and Ecological Impacts From 25 Years of Alum Additions to Lake Holden

Harvey Harper

Environmental Research & Design, Belle Isle, Florida

Lake Holden is a 263-acre land-locked urban lake located in Orlando, Florida. The 741-acre watershed is densely developed with industrial, commercial, and residential land use. Continued inputs of untreated stormwater runoff over many years caused severe water quality degradation in Lake Holden with hyper-eutrophic conditions characterized by elevated nutrient concentrations, severe algal blooms, and fish kills. During the early 1990s Lake Holden ranked second only to Lake Apopka as the most polluted lake in Central Florida.

Alum stormwater treatment was initiated during 1995 for the 3 major runoff inflows which reduced in-lake TP concentrations by approximately 50%. Alum sediment inactivation projects were conducted during 2005–2006 and 2010, further reducing in-lake TP concentrations to 10 ppb and converting the lake to oligotrophic conditions. Since 1995, approximately 875,000 gallons of alum have been added to Lake Holden, equivalent to an areal dose of 187 g Al/m^2. Sediment core samples were collected during 2003, 2007, 2008, 2012, and 2020 which show a reduction in available sediment P and increases in aluminum-bound P. A wide variety of submerged vegetation has blanketed the lake bottom to depths of 10 ft or more. A 2012 study by the Florida DEP concluded that Lake Holden has an extensive, stable, and healthy plant community, dominated primarily by native beneficial aquatic plants. Phytoplankton data indicate stability and balance in the algal community with a low potential for harmful algal blooms. Macroinvertebrate data suggest stability and balance in the benthic community, which is composed of macroinvertebrates usually associated with good water quality.

Evaluation of Phosphorus Treatment Using Microcosm Experiments, Spanaway Lake, Washington

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Spanaway Lake, a natural 270-acre kettle lake located near Tacoma, Washington, is experiencing increasingly severe hazardous algal blooms (HAB) and nuisance aquatic plant growth. It has an average depth of 16 feet (maximum 28 feet) and is dominantly (~65%) groundwater fed. The lake is P-limited and classified as mesotrophic with total phosphorus (TP) ~20 μg/L. Upstream of the lake TP of surface water and groundwater ranges from 20–40 μg/L. The lake experiences thermal stratification in the spring and summer, but the hypolimnion develops little or no P enrichment, implying minimal nutrient flux from bottom sediment. In places this organic-rich sediment is > 4 m thick and likely limits groundwater input. However, near the edges of the lake (< 2 m water depth) groundwater vents have been discovered and these appear to be a significant source of P loading. These are recognized by low DO, 2–6 °C summer colder water, and elevated P (TP up to 74 ppb), and they are particularly vigorous (produce sand boils) after storms.

We are using microcosm experiments to assess a relatively new P-sequestering treatment option: zero valent iron, which is cheaper and more environmentally friendly than other options. Several 3 ft diameter floating rings were deployed with poly curtains to the bottom of the lake over the two bottom types (organic mud vs. gravel/cobbles at active vents) in different depths and environments. We are testing different ways to keep the treatment media in place despite increasing the groundwater flow rates in the winter wet season.

Interactive Session C2: Fisheries Management

November 18, 2020 | 12:00 – 13:30

Developing Automated Systems for Removing Common Carp During Spawning Migrations

Przemek G. Bajer[1,2], Peter J. Hundt[1], Emil Kukulski[3], and Matt Kocian[4]
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Common carp (*Cyprinus carpio*) is an invasive fish that can degrade lake water clarity, but for which management techniques are poorly developed. Such is the case in the Long Lake / Lino Chain of Lakes system in Minnesota, where high carp density is contributing to algae blooms. Here, we present our efforts towards developing automated systems for removing carp during spawning migrations between lakes over a three-year period. We used PIT tags (> 1,000) and antennas to monitor migrations and evaluate our efforts. We used a low-voltage electric guidance system (EGS) to funnel migrating carp towards various removal devices. In 2018, we used the EGS to funnel carp towards a floating fish ladder and a Whooshh removal system. While the EGS performed well (over 90% carp blocked), carp did not ascend the ladder and removal was unsuccessful. In 2019, we funneled carp towards a large (5 m × 26 m) enclosure net. The EGS blocked 95% of the migrating carp, of those ~40% entered the net. Nearly 1,000 could be removed in a day and 4,352 were removed overall (18% of population), but labor costs were high. In 2020, we used the EGS to direct the carp into an enclosure and used portable electrodes and conveyors to remove carp with minimal labor. A successful proof of concept test of that system was conducted in April 2020. Overall, the combination of EGS, portable electrodes, and submersed conveyers should allow for removal of common carp during spawning migrations with minimal labor.

Changes to Water Quality and Sediment Phosphorus Forms in a Shallow, Eutrophic Lake After Removal of Common Carp (*Cyprinus carpio*)

Brian J. Huser[1], Przemyslaw G. Bajer[2], Steve Kittelsen[3], Scott Christenson[4], and Kevin Menken[5]
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Pickerel Lake (Minnesota, USA) is a shallow, polymictic lake that has had problems with eutrophication for decades. Although excess nutrient loading has been a problem in the past, the dominance of common carp (*Cyprinus carpio*) was considered to be a substantial factor driving and sustaining eutrophic conditions. To remove carp and restore the fish community, the lake was treated with rotenone in late 2009 and then restocked with native species. All water quality variables improved after carp removal, with mean values (May–September) for chlorophyll *a*, total phosphorus (P), and turbidity decreasing by 80% to 93% and Secchi disk transparency increasing nearly 600% when comparing means of pre- to post-treatment years. Macrophyte coverage also improved, from means of 4.6% (pre-treatment) to 90% after treatment, indicating a shift from an algal to macrophyte-dominated system. Sediment P storage increased significantly after carp removal as well, with labile (releasable) forms of P increasing in the upper 10 cm of sediment in all cores (N = 7). The decrease in water column P equaled the increase in labile sediment P forms after treatment, indicating carp were a key driver of P transport from sediment to water. The results of this study indicate that an ecological (*i.e.*, both abiotic and biotic) approach is needed when managing eutrophic lakes, as management of nutrients alone will not likely be adequate to restore water quality in systems dominated by carp or other large benthic feeding fish.

*Species and Lakeshore Development Effects on the Relationship Between Fish Abundance and Catch Rates

Camille Mosley[1], John Caffarelli[1], Colin Dassow[1], Alex Ross[2], Greg Sass[3], Chris Solomon[4], and Stuart Jones[1]
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Recreational fisheries are important common pool resources due to their social, economic, and ecological importance. Two important interactions that link the social and ecological components of recreational fisheries are shoreline development and the relationship between fish abundance and angler catch and effort. Increases in building development may have influences on fish behavior due to the negative correlation between coarse woody habitat, which is utilized by many species of fish, and building density. Hyperstability can occur when catch rates are not proportional to abundance. Understanding this mechanism is important because as fish abundance decreases anglers cannot sense the decline in catch rates resulting in continued angling on population levels vulnerable to collapse. To determine whether hyperstability differs across species or gradients of shoreline development we completed an analysis of Wisconsin Department of Natural Resources fisheries data to observe the relationship between catch rate and abundance for popular sport fish in the region, including Bass, panfish, and Walleye populations. All species showed evidence of catch hyperstability, but the magnitude of non-linearity in the relationship between catch and relative abundance differed across species. For some species there was an effect of lakeshore development on the strength of hyperstability. Because hyperstability decreased with shoreline development, catch rates are a more reliable indicator of fish abundance in developed lakes. Differences in hyperstability across species suggest that if managers want information about fish population sizes, they need to conduct standardized independent surveys of fish population size because angler catch rate information is unreliable.

Carp Management Results in a Vegetation Response but Proves Not to Be a Silver Bullet for Deep Lake Management

Jill Sweet, Tom Langer, Brian Beck, and Anna Brown
Minnehaha Creek Watershed District, Minnetonka, Minnesota

From 2014 to 2016 Minnehaha Creek Watershed District (MCWD) partnered with the University of Minnesota to assess the impact of common carp on several lakes within the Six Mile Creek-Halsted Bay Subwatershed, which included a dimictic lake with a large littoral area that was impaired for excess nutrients (Wassermann Lake). The carp assessment indicated the average carp biomass was 523 kg/ha. In 2017, MCWD implemented a carp management project that targeted reducing carp biomass below 100 kg/ha to restore habitat and improve ecosystem health of Wassermann Lake. MCWD has taken a comprehensive approach to manage carp consisting primarily of three management strategies that include adult biomass removal, restricting movement, and suppressing recruitment to ensure success. The carp biomass in Wassermann Lake was reduced to an average of 56 kg/ha in 2018–2019. The reduced density of carp resulted in an increased occurrence and biovolume of curlyleaf pondweed in the spring. By midsummer there did not appear to be significant change in species richness, biovolume, occurrence, maximum depth of plant growth, or water clarity. These results suggest that the impact of reduced carp densities in Wassermann Lake are seasonal and limited. These results also suggest that the water quality response to common carp management in dimictic lakes is difficult to predict since it is dependent on the percentage of area disturbed by carp, watershed loading, sediment phosphorus release, and maximum depth. Continued management efforts targeting internal load will be the necessary next step to meeting water quality standards and habitat goals.

Interactive Session D1: Shoreline

November 18, 2020 | 14:00 – 15:30

Michigan Inland Lakes Shorelines: The Good, the Bad and the Ugly

Ralph Bednarz[1], Jo Latimore[2], and Paul Steen[3]
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Inland lake shorelines have been under increasing developmental pressure since the boom of the cottage industry in Michigan, post-World War II. The transition from seasonal cottages to part-time second homes, as well as full-time residential homes, over the last seventy years has accelerated the transformation of natural to developed shorelines on Michigan inland lakes. When lakeshore lots are developed native trees, shrubs and natural ground cover are typically replaced by lawns. Native aquatic plants and coarse woody habitat are also removed from the shoreline and in the lake. The loss of natural shorelines and shore-lands is the biggest threat to the overall health of Michigan inland lakes.

This analysis incorporates several lake shoreline survey techniques to assess the current status of the shorelines and near-shore zones of Michigan inland lakes. Michigan's volunteer Score the Shore program has assessed shoreline status for five years (2015–2019) and found the median overall shore score of 73 with an overall shore score range of 38–98 (0–100 scale) in 65 lakes. The median total littoral zone score is 66 with a range of 32–100 (0–100 scale) in 65 lakes. The median total riparian zone score is 65 with a range of 27–100 (0–100 scale). The median total erosion control score is 85 with a range of 32–100 (0–100 scale). The median building density (buildings and docks) for the 65 lakes assessed is 10.7 structures per 1000 feet of shoreline with a range of 0–66.7 structures per 1000 feet. These results are compared with the 2012 Michigan National Lakes Assessment which found Lake Habitat Complexity, which is based on lakeshore and shallow water indicators, and Riparian Vegetation Cover were the most widespread stressors. Fifty percent and 48% of Michigan inland lakes, respectively, are estimated to be in the most disturbed condition for these habitat indicators.

The importance of statewide education and outreach programs and local government controls for lakeshore protection are also discussed.

*Use of Ground-Based LiDAR 3D Scanning to Measure Shoreline Erosion in Response to Waves and Wakes

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The land-water interface is highly dynamic and water motion is a key factor that shapes the ecotone because it moves material. Eroded material is added to the waterbody and during the transition, nutrients associated with the resuspended material are susceptible to release which can contribute to nearshore productivity (eutrophication). We are particularly interested to quantify the amount of material and nutrients resuspended in response to waves (natural-caused disturbances *e.g.*, wind) and wakes (human-caused) because lakes that experience high recreational activity likely do so on 'calm' days when wind-generated waves would be negligible. This means that there is no or little reprieve in the nearshore from disturbances (windy days results in wave disturbance, clam days result in wake disturbance) during the growing season which could result in accelerated degradation of water quality. Here we detail the use of a Leica C10 ground-based terrestrial laser scanner (LiDAR) to measure changes in the shoreline of Big Payette Lake, Idaho, USA in response to waves and wakes at sub-centimeter accuracy. Accretion or erosion were related to shoreline topography, water level in the lake, wave type, and shoreline composition. We envision that quantifying the contribution of wakes to dynamics in the nearshore environment will provide an important tool for policymakers to make science-based decisions such as setting "no wake zones" to protect shorelines and the overall lake environment.

Using Pre-vegetated Blankets to Achieve Instant Results

Robert Livingston
GreenLine Synergy, Twin Lakes, Wisconsin

What are pre-vegetated blankets? Pre-vegetated blankets provide all the components of a traditional erosion control blanket with the added benefit of vegetative cover. All blankets are grown to specification (typically a 4–6-week lead time) from pure live seed, Department of Transportation (DOT) and native seed mixes. Pre-vegetated blankets work in a variety of projects such as ditch lines, drainage channels, roadsides, stormwater management areas, green roof installations, steep slopes, shorelines, streambanks, wetland restorations, woodland preservation, prairies, bioretention facilities, rain gardens, golf courses, athletic fields and many more.

GreenLine's pre-vegetated blankets have been used in various projects such as the following (with brief description):

- Private Residence – Wisconsin Dells, Wisconsin Area – Steep slopes often present challenges when it comes to re-vegetation by being difficult to negotiate, unstable, and dry. Pre-vegetated blanket can help minimize disturbance while maximizing erosion control through the use of live vegetation.

- Highway Landscapers Incorporated – Middleton, Wisconsin – Each crop is custom grown to specification. This commercial DOT project started with empty trays which became overflowing trays of vegetation at the time of shipment.

- Village of Fontana – Fontana, Wisconsin – Blankets can be grown to meet the needs of any site. The banks of this drainage stream were lined with pre-vegetated blanket seeded for different flow rates.

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

Columbus, Ohio Reservoir Land Stewardship Program

Nicholas Revetta[1], Kate Moran[2], Matthew Petty[1], Matthew Teitt[3], and Charlie Allen[3]
[1]CDM Smith, Columbus, Ohio; [2]CDM Smith, Cincinnati, Ohio; [3]Stantec, Columbus, Ohio

The Hoover, O'Shaughnessy, and Griggs Reservoirs are owned and operated by the City of Columbus, Ohio (City) and provide drinking water to over 1.2 million people while simultaneously offering over 4,000 acres of recreational opportunities. Maintaining a native shoreline buffer adjacent to these waters is important for overall water quality and reservoir health. Vegetated shoreline buffers are a commonly used water resource management tool which naturally provides a variety of environmental benefits including protecting water quality, stabilizing shorelines, mitigating flood flows, providing habitat for fish and wildlife, and improving natural aesthetics.

The City property surrounding these reservoirs is adjacent to approximately 1,200 private residential properties, many of which encroach on the City owned shoreline buffers. The goal of the Land Stewardship Program is to protect the water quality and ecological resources of these reservoirs while supporting shoreline access through standards governing allowable activities. With the help of CDM Smith and Stantec, the City has created guidelines to reestablish or maintain healthy native shoreline buffers while permitting the adjacent landowner access to create a path, establish a view corridor, remove invasive/noxious species, and/or install a boat dock in accordance with newly developed Land Stewardship Standards.

Following field shoreline assessments that used an ArcGIS Online platform and tablets for rapid and accurate collection of existing conditions data, individual design plans were established for each adjacent landowner identifying where permitted activities/structures are allowed on the reservoir buffers, resulting in an enlarged, contiguous buffer that balances environmental protection, recreational needs, and private interests.

Interactive Session D2: AIS

November 18, 2020 | 14:00 – 15:30

Drivers of Species Richness, Biomass, and Dominance of Invasive Macrophytes in Temperate Lakes

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Presence and abundance of invasive species depend on likelihood of introduction and environmental limitations to their distributions. Propagule pressure and anthropogenic disturbance are hypothesized to increase invasions yet assessing the importance of propagule pressure and anthropogenic factors independently is challenging, and properties of invaded systems (*e.g.*, habitat availability) likely contribute to invasions. We sampled macrophyte assemblages in 20 lakes in New York, varying in boater visitations and number of previous waterbodies visited, to test if increased propagule risk (proxy for propagule pressure measuring potential for introducing invasives from different sources) resulted in greater species richness, biomass (g/m^2) and dominance (% invasive biomass) of invasive macrophytes. We then tested watershed land use, in-lake water properties, and lake morphology on presence, abundance, and dominance of invasive macrophytes. Increased propagule risk resulted in greater species richness of invasive macrophytes. In invaded lakes, increased abundance of invasive macrophytes was correlated with increased agriculture in watersheds and littoral:total area ratio. Results suggest propagule risk can explain spatial variability in macrophyte invasions, while abundance in invaded lakes can be correlated with watershed and lake morphology. In lakes with increased suitable habitat (greater littoral:total area ratio), invasive macrophytes may dominate aquatic plant assemblages. Many factors correlated with the abundance of invasive macrophytes are not easily managed (*e.g.*, watershed agricultural land use and lake morphology). Limiting introductions of propagules is likely to best approach to prevent macrophyte invasions, especially at high risk lakes.

Advancements in Eurasian Watermilfoil Research and Management in Wisconsin

Michelle Nault
Wisconsin Department of Natural Resources, Madison, Wisconsin

In order to better understand the impacts of Eurasian watermilfoil (*Myriophyllum spicatum*) on Wisconsin lakes, Department of Natural Resources staff have worked in close collaboration with numerous stakeholders to compile over 15 years' worth of quantitative data collected on hundreds of waterbodies across the state. This data is being used to help develop and implement plans for strategic and efficient monitoring and management of this non-native aquatic plant. Specifically this presentation will discuss the current statewide distribution, abundance, and genetics of watermilfoil in Wisconsin, the results of a long-term watermilfoil monitoring project, as well as a discussion on the efficacy and selectivity of several currently utilized management techniques. The results may surprise you, and challenge some commonly held beliefs about the ecology and management of this aquatic invasive species.

Early Detection and Assessment of Water Bodies Most at Risk of Colonization by a New Species of Water Chestnut in the Potomac River Watershed

Ian Pfingsten[1] and Nancy Rybicki[2]
[1]US Geological Survey, Gainesville, Florida; [2]US Geological Survey, Reston, Virginia

A new introduction of a relative of Eurasian water chestnut (*Trapa natans*) was discovered in northern Virginia in 2014. This *Trapa* species is characterized by two-horned fruits, pink flowers, and red abaxial leaf surfaces. Its distribution was verified by vouchers sent to local herbaria, extension agents, pond managers, and online invasive species databases. The locations and information on the first year of colonization, current size of colonies, recent management efforts, and verification photos were incorporated into the USGS Nonindigenous Aquatic Species database (nas.er.usgs.gov). By 2019 a study of populations around the world revealed that its name is *T. bispinosa* Roxb. var. *iinumaii* Nakano, and its DNA and morphology matched samples of this morphotype in Taiwan. Literature review and current data suggest that early detection and rapid response could help manage the distribution and spread of *T. bispinosa*. Site visits indicated that waterfowl may be dispersing *T. bispinosa* to new waterbodies by epizoochory on plumage. A risk assessment was conducted using an estimated three km radius for waterfowl dispersal. We located 520 at-risk waterbodies within three km of active populations in 2019. The top ten largest colonies in 2019 had between 2,000 – 10,000 m^2 of *T. bispinosa* coverage and only one site was actively managed. Follow up efforts will be needed to locate and confirm new populations using aerial imagery and ground surveys. Potential impacts are yet to be determined but its close relative, *T. natans*, has a high-risk assessment, indicating resource managers should be alerted to this potential threat.

Interactive Session E1: APMS/NALMS HAB Management

November 19, 2020 | 13:30 – 15:00

Proactive Applied In-Lake Management for the Prevention of Hazardous Algal Blooms (HABs)

Marc Bellaud
SOLitude Lake Management, Shrewsbury, Massachusetts

Similar to what has occurred with technology, the science of applied lake management has evolved considerably over the past 40 years, just as the North American Lake Management Society has evolved. This evolution has occurred partly because of scientific advancements and partly out of need. Pressures from continued development, agricultural practices, climate change, greater recreational usage and increasing water demands are adversely impacting lakes at an accelerated rate. Fortunately, there is greater awareness of the challenges, and applied lake managers now have more tools at their disposal than ever before.

Lake management needs and solutions vary considerably depending on the type of waterbody, its uses, geographic location and the particular challenges it is facing. Many of the old axioms remain true. First, every lake and pond is different. This needs to be taken into account as lake management plans are being developed. Assessment, monitoring and even permitting requirements must be appropriate for the size and type of waterbody, and for the management strategy being proposed. Second, prevention is the most effective form of management. No one can dispute that eliminating nutrient sources in the watershed is better than trying to control harmful algal blooms (HABs) once they develop in a nutrient-rich system. However, the unfortunate reality is many of our lakes have already been adversely impacted, and in-lake management is often needed to preserve desirable conditions and to prevent further deterioration.

There are four major focus areas of applied in-lake management in most freshwater lakes, ponds and reservoirs: improving water quality, eliminating aquatic invasive animal species, managing problematic harmful algal blooms, and controlling invasive and nuisance aquatic weed growth. Many of the techniques and strategies used to manage these challenges are similar. This presentation will focus on improving water quality via nutrient inactivation and cutting-edge aeration technology, and managing problematic HABs in-lake both proactively and reactively. In addition, we shall discuss the partnerships and collaborative efforts of a lake management firm engaging with various stakeholders to achieve these lake management goals.

Consideration of Algaecide Strategies to Complement Proactive HAB Management

West Bishop[1] and Kenneth Wagner[2]
[1]SePRO Research and Technology Campus, Whitakers, North Carolina; [2]Water Resource Services, Wilbraham, Massachusetts

Proactive measures for HABs such as watershed improvement are critical to keep nutrients from entering aquatic systems. In-lake measures such as nutrient mitigation and mixing should also be considered to offset blooms. However, in some systems (*e.g.*, flowing canals, high turnover drinking water reservoirs, dendritic shallow reservoirs), proactive measures may not be feasible or fall short in achieving desired objectives. Moreover, even with proactive measures, some cyanobacteria may still bloom. Many cyanobacteria have unique adaptations for acquiring nutrients, can thrive under mixed conditions, or have already become established in a system. If proactive measures fail or have not yet been implemented, the potential negative impacts of direct treatment must be weighed against the major health and ecological risks of letting the bloom run its course. This goal of this presentation is to give an overview of potential use of algaecides in an integrated management program. When used appropriately, these can complement other longer-term management initiatives. Upon assessment, many sites may already have an existing infestation of harmful or toxic algae, and this often requires direct and immediate intervention to offset risks to humans and wildlife and restore water uses. Strategic and efficient application of algaecides, in concert with tracking algal communities, can facilitate a rapid response that avoids a significant bloom and provides effective and short-term relief. Overall, a review of algaecides as a rapid-response strategy for HABs will be provided including what categories of algaecide options are available, their effective use strategies at specific sites, and potential risks toward consideration for improved management integration in concert with other approaches.

Use of Monitoring Data to Evaluate an In-Lake Aeration System and a Watershed-Scale Approach to Reduce Cyanobacteria Blooms in a Vermont Lake

Oliver Pierson[1], Angela Shambaugh[1], and Perry Thomas[2]
[1]Lakes and Ponds Program, Watershed Management Division, Vermont Department of Environmental Conservation, Montpelier, Vermont;
[2]Watershed Management Branch, Division of Water, Kentucky Energy and Environment Cabinet, Frankfort, Kentucky

Recurring harmful cyanobacterial blooms in lakes and reservoirs pose complex challenges to lake and watershed managers. During the past five years, in the Lake Carmi watershed of Vermont, partners collaborated to implement actions prescribed by the 2015 Vermont Clean Water Act (Act 64). Concurrently, the Vermont Department of Environmental Conservation (VTDEC) used monitoring data to demonstrate how internal phosphorus loading and repeated mixing events supported late season harmful cyanobacterial blooms, ultimately justifying an in-lake management approach.

Presentations based on weather and monitoring data from 2017 convinced community members, legislators, technical partners, and VTDEC leadership to support installation of a large-scale aeration system in Lake Carmi in June 2019. Biweekly monitoring through the summer of 2019 allowed evaluation of the aeration system. Concurrently, harvesting of Eurasian milfoil from Lake Carmi was held constant, and macrophyte populations were surveyed to assess changes caused by aeration. Preliminary results from 2019 show that the aeration system successfully mixed the water column to allow dissolved oxygen to reach the lake bottom, thereby significantly reducing internal phosphorus loading from lake sediments.

The Lake Carmi collaboration effort, in which the Vermont Lakes and Ponds Program led an integrated approach with multiple partners to manage harmful cyanobacteria blooms, serves as a model for other inland lake restoration efforts in Vermont. Fortunately, Act 64 provides a framework for multi-sector actions in lake watersheds, including installation of agricultural best management practices, improvement of public roads, and restoration of wetlands and riparian zones, that can collectively improve water quality.

Strategies for Preventing, Managing, and Responding to Harmful Cyanobacteria Blooms

Angela Shambaugh[1], Ben Holcomb[2], and Cherri Baysinger[3]
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Cyanobacteria blooms are a common occurrence across North America and elsewhere. In some cases, they may produce potent toxins harmful to people and animals. Harmful cyanobacteria blooms (HCBs) can negatively impact drinking water systems, recreation, fishing, aquatic habitat, and property values. During bloom events immediate response and communication are very important. For the rest of the year, thoughtful watershed management can reduce the frequency and severity of future HCBs.

No management strategy will be effective in every water body or watershed. Local characteristics, environmental triggers, and human activities must all be considered to use HCB prevention and management strategies successfully. Monitoring is key to identifying what supports cyanobacteria growth and evaluating whether your strategies have been successful. Consistent, informative, effective communication helps protect your community and builds supports for implementation of your cyanobacteria response plan.

The Interstate Technology and Regulatory Council's (ITRC) HCB team has developed a guidance document for state regulators and others managing HCBs in freshwater systems. Our guidance is intended to help you select monitoring, communication, in-lake management, and nutrient reduction approaches that are suitable for use in your water body and community. We also recognize the need for rapid response during bloom events, highlighting information and actions that are key when time is critical. During our presentation, we will introduce you to the guidance document, embedded selection tools, and resources that will be available to assist you when responding to HCB events.

Interactive Session E2: Salt

November 19, 2020 | 13:30 – 15:00

Is Salinity Stratification From Winter Salt Applications Impairing the Performance and Effective Volume of Urban Stormwater Management Ponds?

Brian Ginn, Chandler Eves, and David Lembcke
Lake Simcoe Region Conservation Authority, Newmarket, Ontario, Canada

Stormwater management (or retention / detention) ponds are primarily constructed for retaining surface stormwater run-off, reducing flooding, and providing passive water quality treatment in urban areas. In the Lake Simcoe Watershed (Ontario, Canada), we carried out a targeted survey of ponds along a gradient of urbanization (residential to commercial / institutional catchments with expansive paved parking lots) and found that ponds were functioning less efficiently than predicted by environmental models, due to several factors. First, run-off laden with winter de-icing salt formed a chemical stratification of the pond water column, which impaired nutrient retention as low dissolved oxygen concentrations oxygen near the bottom facilitated the release of sediment-bound phosphorus. Second, this released sediment-bound phosphorus is readily used by organisms (aquatic plants and algae), or flushed from the pond if a large rainfall event occurs and mixes the water column, leading to higher loading of biologically-available phosphorus in the receiving waters designed to be protected by the pond. Third, the higher the salinity of the pond bottom waters, the more resistant the pond was to mixing of the water column, leading to many precipitation events flowing through the pond untreated, on top of the saline bottom water layer, and directly into receiving waters. Finally, some ponds in residential areas have persistent elevated turbidity due to the presence of goldfish, likely released by residents living near the pond, which keep pond sediments suspended and further impair stormwater pond functioning.

Field Test of Brine as a Best Management Practice for Reducing Winter Road Salt in Stormwater

Danelle Haake[1] and Jason Knouft[2]
[1]National Great Rivers Research and Education Center, East Alton, Illinois; [2]Saint Louis University, St. Louis, Missouri

Sodium chloride salt is commonly used as a road deicer during winter snow and ice storms. As the salt dissolves in the meltwater, it is conveyed through stormwater systems into local freshwater ecosystems where it may harm aquatic life. Brining is an anti-icing best management practice (BMP) that involves the spraying of dissolved salt onto the pavement prior to winter storms. This BMP is used by departments of transportation and municipal public works to prevent the initial accumulation of snow and ice, with the intent of using less salt than would be required to achieve the same road clearing effect with solid rock salt. In this study, we examine the effectiveness of brining as a salt-reduction BMP on residential roads in six cities in St. Louis County, Missouri. Stormwater chloride loads were estimated using conductivity loggers and water level loggers set to record at 5-minute intervals in 24 stormwater pipes. Calculated chloride yields were compared in three pairs of cities; one city in each pair utilized brining while the other relied primarily on solid rock salt. During the nine winter storms that were evaluated over the two-year study period, cities using brine as a BMP had significantly lower chloride yields than those without brine systems.

Chloride Trend Analysis in an Urban Shallow Lake

Chris Kucek[1], John Manske[2], and Mark Houle[1]
[1]Capitol Region Watershed District, St. Paul, Minnesota; [2]Ramsey County Public Works, Arden Hills, Minnesota

Como Lake is a popular 70.5-acre shallow lake in St. Paul, Minnesota that is heavily impacted by stormwater runoff from the surrounding urban watershed. In 2014, Como Lake was listed as impaired for excessive chloride by the Minnesota Pollution Control Agency (MPCA) for exceeding the chronic state standard of 230 mg/L. Chronically elevated levels of chloride can directly harm native freshwater organisms by disrupting osmoregulation, and there is currently no practical method to remove chloride from fresh water bodies. Depth and surface chloride concentrations were sampled from 1984–2020 by Ramsey County Public Works (RCPW) in partnership with Capitol Region Watershed District (CRWD). Samples were analyzed by year, season, and depth to understand chloride trends within Como Lake. Continuous conductivity readings measured in the hypolimnion by a sonde from April to October in 2017–2019 were correlated with sampled chloride concentrations. Regression analysis found a strong correlation between chloride concentrations and conductivity (R^2 = 0.88). This relationship was used to model chloride concentrations during this time and showed that conductivity measurements can be used as a surrogate for chloride sampling in Como Lake. Average chloride concentrations in Como Lake are increasing in the entire water column, with especially high readings found in the hypolimnion during winter and spring. Continued monitoring year-round will be needed to document future changes to chloride concentrations in the lake as statewide deicing best management practices and regulations are adopted and as impacts to the aquatic ecosystem are observed.

*Assessing the Impact of Salinization (NaCl) on the Survival and Reproduction of Two Dominant Cladocera Species (*Bosmina longirostris* and *Chydorus brevilabris*)

Robin Valleau[1], Martha P Celis-Salgado[1], Shelley Arnott[1], Andrew Paterson[2], and John Smol[1]
[1]Queen's University, Kingston, Ontario, Canada; [2]Ontario Ministry of the Environment, Conservation and Parks, Dorset, Ontario, Canada

Salinization of freshwater lakes, largely linked to road salt runoff, is a serious threat to zooplankton across North America. Road salt was listed as a priority substance in Canada in 2001, which was followed by the establishment of a Canadian Water Quality Guideline (CWQG) for chloride (Cl^-) for the protection of aquatic life (120 mg/L). Similarly, the United States Environmental Protection Agency (EPA) has recommended a chronic water quality criterion of 230 mg/L. The CWQG was set using long-term LC50 data from 28 species; despite their importance in freshwater ecosystem, only four zooplankton taxa were used (three Daphnia and one rotifer). Many lakes with elevated Cl^- concentrations are shallow and therefore are not ideally suited to the pelagic species used to set the CWQG. To evaluate this potential issue, two Cladocera species that are common to shallow lakes in the region (*Bosmina longirostris* and *Chydorus brevilabris*) were selected as test organisms for an experimental study. A series of 14-day bioassay experiments were conducted with eight different Cl^- treatments (ranging from 0.4 mg/l to 1200 mg/L) using a softwater medium, which reflects chemical conditions observed in Precambrian Shield lakes. Surprisingly, both *C. brevilabris* and *B. longirostris* had LC_{50} values below the CWQG for Cl^- (LC_{50} = 44.5 mg/L and 24.3 mg/L Cl^-, respectively), and a significant reduction in neonate production was observed for both taxa at a Cl^- concentration of 15 mg/L. Our results demonstrate that the CWQG for Cl^- is insufficient to protect aquatic life in shallow Precambrian Shield Lake.

Interactive Session F1: HABs

November 19, 2020 | 15:30 – 17:00

Monitoring and Mitigating Harmful Algal Blooms at Drinking Water Sources in Ohio

Ruth Briland

Ohio Environmental Protection Agency, Columbus, Ohio

Cyanobacteria and the toxins they produce pose a challenge for drinking water treatment and threaten human health. Early detection in source waters is necessary to mitigate the bloom and optimize treatment process to remove cyanotoxins and ensure that finished water is safe to consume. Public water systems that use surface source waters in Ohio are required to monitor for microcystins and cyanobacteria screening for cyanotoxin-production genes. Additionally, Ohio's Surface Water program prioritized lake assessments for drinking water sources. This presentation will provide a summary based on these monitoring programs and document the occurrence of cyanotoxins across Ohio lakes, reservoirs, and rivers used for drinking water sourced during 2016–2020. The cyanotoxin occurrence data is also used to identify waters that are not meeting water quality goals for drinking water use and listed as impaired in the Ohio's Integrated Water Quality Monitoring and Assessment Report for 2020. We will include case studies on mitigation efforts, reservoir management strategies, and nutrient reduction to reduce the occurrence of cyanobacteria blooms.

Role of Harmful Algal Bloom Data for Risk Management in Minnesota

Matt Lindon

Minnesota Pollution Control Agency, St. Paul, Minnesota

With a diverse population of waters and dynamic nature of algal toxins, it can be challenging to manage HABs in Minnesota. However, extensive HAB monitoring and targeted research efforts provide Minnesota with a robust cyanotoxin dataset. The goal of the presentation is to make use of this information so that local lake managers are provided with a better understanding of the complexities of HABs along with additional resources for dealing with HABs. This presentation will first use these data and research to describe the extent and frequency of HAB in Minnesota. In this vein, recent research on lake stratification and nitrogen will be discussed as a basis to improve HAB predictions. Secondly, I will share how Minnesota has used this information to update its toolbox of HAB resources including: state algal toxin guidance values, monitoring options, communication and advisories.

Cyanobacteria Bloom Response

Doug Pullman
Applied Biochemists, Alpharetta, Georgia

HABs are increasingly becoming a "front and center" topic as a media coverage increases and as a greater concern for State agencies. The EPA and many States have recently established guidance levels for several common cyanotoxins while the lake management industry has begun to provide better means, methods, and strategies to monitor, analyze, and manage potentially toxic (PTOX) HABs. PTOX HAB management is distinctly different from nuisance plant and algae management because of the strong public health implications associated with monitoring and management decisions. Failure to respond to PTOX HAB conditions may also have serious implications. A proper response plan must depend on regular monitoring that may involve lake residents, consultants, lake management practitioners, local and State agencies. Establishing appropriate trigger points for further action is difficult with dynamic biological systems but must be established with the input and cooperation of a wide range of stakeholders that includes lake residents, local governments, the media, contractors, and State agencies. Since a relatively few numbers of species are responsible for creating PTOX HAB conditions, selective species management is required to minimize disturbance to aquatic ecosystems since many PTOX species are encouraged by indiscriminate anthropogenic disturbance.

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

Assessment of Cyanobacterial Harmful Algal Blooms in Greenwood Lake, New York-New Jersey

Meiyin Wu, Yaritza Acosta-Caraballo, Anne Hurley, T. David Hsu, and Alessandra Rossi
Montclair State University, Montclair, New Jersey

Greenwood Lake is an interstate lake of New York and New Jersey, and is a popular destination for fishing, outdoor recreation, and water sports. In July 2019, the bi-state Greenwood Lake Environmental Commission suspected an on-going event of cyanobacterial harmful algal blooms (CyanoHAB) and initiated an assessment at 15 sites, 7 in New York and 8 in New Jersey. The study sites were selected strategically to include beaches, marinas, a state park, inlets, and an outlet. Water temperature, dissolved oxygen, pH, specific conductance, total suspended solids, total Kjeldahl nitrogen, total phosphorus and *E. coli* were monitored to assess the water quality; phytoplankton community composition, cyanobacterial cell counts, chlorophyll *a*, and microcystins were investigated to evaluate the severity of CyanoHAB. A total of 14 cyanobacteria taxa were documented, dominated by *Microcystis*, *Dolichospermum*, *Aphanizomenon*, *Woronichinia* and *Pseudanabaena*. Cyanobacterial cell counts ranged from 3,035,958 to 49,452 cells/mL; all 15 sites were confirmed as having on-going CyanoHAB based on the criteria established by New Jersey Department of Environmental Protection (NJDEP). Nine of the 15 study sites were found to have microcystins over the NJDEP established threshold of 3 μg/L. Ten study sites were documented to have greater than 50 μg/L of chlorophyll *a*, another common indicator of algal blooms. Additionally, elevated total phosphorus levels were documented at all study sites, ranging from 1.39 to 0.078 mg/L. The southern (New Jersey) portion of the lake was found to be experiencing more severe CyanoHAB; which led to the recommendation against water sports and recreation activities.

Interactive Session F2: Internal Loading

November 19, 2020 | 15:30 – 17:00

Minnesota State and Regional Government Review of Internal Phosphorus Load Control – A "White Paper" to Guide Public Funding of Lake Restoration Projects

Jesse Anderson[1], Pam Anderson[2], Brian Johnson[3], Shaina Keseley[4], Scott MacLean[5], Elizabeth Nebgen[6], Nick Proulx[7], and Greg Van Eeckhout[8]

[1]Minnesota Pollution Control Agency, Duluth, Minnesota; [2]Minnesota Pollution Control Agency, St. Paul, Minnesota; [3]Metropolitan Council, St. Paul, Minnesota; [4]Minnesota Board of Water and Soil Resources, Rochester, Minnesota; [5]Minnesota Pollution Control Agency, Mankato, Minnesota; [6]Minnesota Pollution Control Agency, Detroit Lakes, Minnesota; [7]Minnesota Department of Natural Resources, St. Paul, Minnesota; [8]Minnesota Pollution Control Agency, Brainerd, Minnesota

Staff from Minnesota State and regional governments recently prepared a document that provides an overview of common practices for internal lake phosphorus (P) load control in Minnesota, at the request of local governments who needed feedback on when to implement lake restoration projects that address internal P loading. The Minnesota Pollution Control Agency, Minnesota Department of Natural Resources, Minnesota Board of Water and Soil Resources (BWSR), and the Metropolitan Council are the government units with regulatory authority over many of the actions that would be part of an internal P load reduction project, or they are closely involved with local lake management planning efforts. The paper's intended audience is state and local lake practitioners, consultants, and agency staff issuing permits or reviewing public grant proposals when considering the use of internal P load reduction practices. The document summarizes current literature on control of internal loading in lakes and internal load reduction methods used in Minnesota lakes, provides planning considerations for projects to address internal loading, and includes information on permitting and approval processes, steps for determining the most appropriate load control option, and managing project expectations. In 2018 BWSR started using the document to check requirements for feasibility studies for funded grants. Other intents for the paper are: guidance for issuing permits, as supplemental information for long-term planning by local units of government, and as a guidance and reference document for permit applicants and planners. The authors appreciate a technical review of the paper by NALMS' Certified Lake Managers Group.

Internal Nutrient Loading in Ultra-Oligotrophic Lake Tahoe, California/Nevada: Implications for Water Quality and Management in a Changing Climate

Marc Beutel
University of California, Merced, California

A warming climate is expected to lead to stronger thermal stratification, less frequent deep mixing, and greater potential for bottom water anoxia in deep, temperate oligotrophic lakes. As a result, there is growing interest in understanding nutrient cycling at the profundal sediment-water interface of these rare ecosystems. In Lake Tahoe, California/Nevada, USA, sediment is a large reservoir of nutrients, with the upper 5 cm containing reduced nitrogen and redox-sensitive phosphorus equivalent to 15 times the annual external load. Experimental results indicate that if deep water in Lake Tahoe goes anoxic, profundal sediment will release appreciable amounts of phosphate (0.13–0.29 mg $P/m^2/d$), ammonia (0.49 mg $N/m^2/d$), and iron to overlaying water. Assuming a 10-year duration of bottom water anoxia followed by a deep-water mixing event, water column phosphate, and ammonia concentrations would increase by an estimated 1.6 mg P/L and 2.9 mg N/L, nearly doubling ambient concentrations. Based on historic nutrient enrichment assays this could lead to a 40% increase in algal growth and enhanced oxygen demand in the profundal zone when algae undergo biodegradation. Iron release could have the dual effect of alleviating nitrate limitation on algal growth while promoting the formation of fine iron oxyhydroxide particles that degrade water clarity. If the depth and frequency of lake mixing decrease in the future as hydrodynamic models suggest, large-scale in-lake management strategies that impede internal nutrient loading in Lake Tahoe, such as bottom water oxygen addition or aluminum salt addition, may need to be considered.

Refining Internal Loading Estimates in Como Lake Using Continuous Dissolved Oxygen Monitoring

Mark Houle, Sarah Wein, and Britta Belden
Capitol Region Watershed District, St. Paul, Minnesota

Como Lake is a 70.5-acre urban shallow lake within Capitol Region Watershed District (CRWD) in St. Paul, Minnesota that has a long history of poor water quality and frequent algal blooms. It has been listed as impaired for nutrients since 2002 with average phosphorus (P) concentrations measuring three-times greater than the State standard (60 µg/L). Excess P in Como Lake is due to decades of stormwater runoff as well as significant increases in internal loading over time. To meet P load reduction goals, current estimations of both external and internal P loads were needed. While external loads have been recently modeled, internal loading needed to be reevaluated to determine current rates.

To accurately calculate internal P loading in Como Lake, three parameters were required: the duration of anoxia, the areal extent of anoxia, and the P release rates from the lake bottom sediments. CRWD created a monitoring plan to collect data to support this calculation by deploying three multiparameter sondes at different locations and depths to continuously record hypolimnetic dissolved oxygen from April to November in 2017–2019. Additionally, lake sediment cores were extracted in 2016 to measure P release rates.

With these data, CRWD could calculate a high-resolution estimate of internal loading rates using known parameters and make better-informed assumptions of anoxic conditions throughout the year. Understanding the extent and magnitude of internal loading in Como Lake was critical in the development of the 2019 Como Lake Management Plan, which defined adaptive management strategies to meet water quality goals.

Internal Phosphorus Loading Dynamics in Some Shallow Wisconsin Lakes

William F. James, Mai Lia Vang, McKenzie Librande, and Conor Dougherty
University of Wisconsin – Stout, Center for Limnological Research and Rehabilitation- Discovery Center, Department of Biology, Menomonie, Wisconsin

Generally, diffusive P flux from sediment under anaerobic conditions is the dominant process of internal P loading in deeper lakes that strongly stratify in summer and exhibit hypolimnetic anoxia. Vertical transport of hypolimnetic P to the epilimnion can be achieved in these lakes by wind-driven mixing and entrainment and biological uptake by vertically migrating algae. In contrast, shallow lakes are polymictic and exhibit only intermittent bottom anoxia throughout the summer. Thus, direct diffusive P flux from sediment and entrainment may account for a much smaller fraction of the overall internal P load in shallow lakes. Other processes such as resuspension, bioturbation, and aquatic macrophyte decay may dominate internal P loading. Examination of P budgets and summer limnological trends in several shallow Wisconsin lakes suggested that directly measured diffusive P flux from sediment accounted for < 50% of the net increase in summer lake P mass. Even though summer external P loading is relatively low, chlorophyll concentrations can increase to > 100 µg/L in August. By process of elimination, many of the typical shallow lake internal P loading processes mentioned above do not appear to account for unmeasured internal P load, leading to speculation that algal resting stages may directly assimilate sediment P and inoculate the water column when conditions are optimal.

Interactive Session G1: Modeling

November 20, 2020 | 12:00 – 13:30

*Hydrodynamic Simulation of Lake Mead to Inform Future Drinking Water Treatment Needs: Water Treatment Plant Modeling with Simulink and BSM1

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

Lake Mead is a large reservoir along the Colorado River that supplies water for drinking and irrigation to nearly 30 million users. Persistent drought conditions have caused a sharp decline in the elevation of Lake Mead, and consequently, a new drinking water intake was constructed at a lower elevation to bolster the water supply to the Las Vegas Valley. As lake levels decline, sediment coming downstream from the Colorado River has the potential to enter the drinking water intake, causing turbidity issues and thus affecting water treatment. To plan for future treatment scenarios, we use the 3D hydrodynamic and water quality model AEM3D to study the effect of lake levels on sediment loads at the Southern Nevada Water Authority's drinking water intake in Lake Mead. Sediment particle sizes and concentrations were determined by fitting a distribution to data collected upstream during high flows. These simulated particle distributions are transported downstream using the hydrodynamic component of AEM3D, and the concentration at the drinking water intake is recorded daily. Simulations were performed over a period of 10 years to quantify seasonal variations, meteorological effects, and long-term effects on the lake. The output of the full AEM3D model is then emulated using a simpler model, which will eventually serve as the initial condition for a water treatment plant model. This simple model will be based off of the so called Benchmark Standard Model 1, which will serve as a gauge to calibrate and properly test the robustness of our models using predefined input datasets which should produce the same outputs every time. This will ensure the accuracy in future predictions of water quality through our new models. In addition to the BSM1 model, several other models for sub-modules specific to the Southern Nevada Water Authority will be implemented in tandem with the BSM1 to properly emulate the water treatment facilities on site.

Hydrodynamic Simulation of Lake Mead to Inform Future Drinking Water Treatment Needs: Lake Modeling with AEM3D

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

Lake Mead is a large reservoir along the Colorado River that has been affected by persistent drought conditions. As lake levels decline, sediment coming downstream from the Colorado River has the potential to enter the drinking water intake. This can cause turbidity issues and thus affect water treatment, especially during high-flow experiment releases from upstream. Further, winter turnover in the lake can cause benthic sediment to become resuspended and potentially increase turbidity at the drinking water intake. To plan for future treatment scenarios, we use the 3D hydrodynamic and water quality model AEM3D to study the effect of lake levels on sediment loads at the Southern Nevada Water Authority's drinking water intake in Lake Mead. Sediment particle sizes and concentrations were determined by fitting a distribution to data collected upstream during high flows. These simulated particle distributions are transported downstream using the hydrodynamic component of AEM3D, and the concentration at the drinking water intake is recorded daily. The output of the full AEM3D model is then emulated using a simpler Gaussian process regression model (GPRM). The GPRM predicts sediment concentration at the drinking water intake for any given lake elevation and date over the 10-year simulation period. This is the first component of a two-part coupled model, where the GPRM serves as an input to a water treatment plant model. The second component of this model will also be presented at NALMS by Jeff Belding.

Developing a HAB Management Plan Using the Lake Loading Response Model

Patrick Goodwin
Vertex Aquatic Solutions, Pompano Beach, Florida

Willow Lake is a small (3 ha) shallow ($\bar{x}$ = 3 m) man-made lake located in North East Florida (USA). A progressive decline in in water quality has been observed over the past ten years with harmful algal blooms (HABs) increasing in frequency, intensity, and duration. Traditional management approaches such as algaecides, aeration, and alum provided limited improvement in addressing water quality and HAB issues. A more detailed investigation into the route cause(s) of water quality degradation were undertaken. A low-cost nutrient budget was constructed, followed by water quality modeling using the lake loading response model (LLRM). Study results found on-site wastewater disposal and watershed run-off represented over 90% of the total phosphorus and nitrogen load to the lake. An integrative HAB management plan was developed to restore the lake both short and long-term. This presentation covers the details of the HAB management plan and demonstrates the utility of water quality modeling in the decision-making process.

Tracer Study and Hydrodynamic Modeling of an Alpine Lake, a Demonstration Case Study

Ali Saber Sichani[1], David E. James[1], Imad Hannoun[2], Erica Marti[1], George William Kajjumba[1], and Tracy Vermeyen[3]
[1]University of Nevada, Las Vegas, Nevada; [2]Water Quality Solutions, McGaheysville, Virginia; [3]US Bureau of Reclamation, Boulder, Colorado

Prolonged drought in the southwestern United States has led communities towards adopting indirect potable reuse (IPR) as an option to augment water supplies.

For a Bureau of Reclamation-funded effort to demonstrate lake modeling for IPR, a calibrated hydrodynamic model was developed for Lake Arrowhead, California, using 18 months of meteorological and water quality data. A December 2019 tracer study using two conservative tracers, Rhodamine WT and sucralose, was conducted to validate the model. Rhodamine WT was measured *in situ* using calibrated fluorometers. Sucralose was measured using Liquid chromatography-mass spectrometry. Two Acoustic Doppler Profilers (ADPs) and thermistor strings were deployed to record velocities and stratification changes.

ADP and thermistor string data showed significant cold water inflows and wind-driven changes in temperature profiles during the tracer study. Due to weak stratification conditions and strong winds, tracer rapidly spread through the top 26 m of the water column within 48 hours and moved across the lake and dissipated in 96 hours. The validated hydrodynamic model's dilution and mixing simulations strongly depended on assigned wind fields. The best model showed root mean square error of 0.2 ppb and mean absolute error of 0.11 ppb, with maximum computed tracer mass recovery of 101.2%.

ADP and thermistor string data demonstrated shifts in water column stratification and water velocity distribution with depth. Modeled water movement and mixing was rapid in non-stratified, windy conditions. The hydrodynamic model was able to adequately simulate mixing and movement during the study period.

Interactive Session G2: Cyanotoxins

November 20, 2020 | 12:00 – 13:30

*Freshwater Neurotoxins and Cyanotoxin Mixtures: A Review and Case Study from Voyageurs National Park, Minnesota (USA)

Victoria G. Christensen[1,2], Ryan P. Maki[3], Erin A. Stelzer[4], Jaime F. LeDuc[3], and Eakalak Khan[5]
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Toxic cyanobacteria are a growing concern worldwide because they can negatively affect humans, animals, and ecosystems. We reviewed studies of anatoxin-a and saxitoxin, two of the most potent of the known classes of cyanobacteria-produced neurotoxins, which are understudied in freshwater environments. Examples of human and animal health concerns can range from acute to chronic. However, few studies have focused on chronic or sub-lethal effects of the neurotoxins. Neurotoxins have been detected in Minnesota lakes, including Kabetogama Lake in Voyageurs National Park. In Kabetogama Lake, we documented the presence of neurotoxin-forming cyanobacteria and neurotoxins at low concentrations. Anatoxin-a was measured at concentrations from less than 0.15 to 0.61 micrograms per liter and saxitoxin was measured at concentrations from less than 0.01 to 0.08 micrograms per liter. Although these concentrations are low, effects of chronic exposure to low concentrations may be far reaching and include consequences throughout the food web. Moreover, neurotoxins often co-occur with other cyanotoxins, including microcystin and Anabaenapeptins, which also were detected in Kabetogama Lake. Therefore, synergistic effects of cyanotoxin mixtures may be an additional concern. Results of our literature review and case study indicate a significant gap in our understanding of cyanotoxins and how they interact in the environment.

Cyanotoxin Occurrence in the United States: A 20-Year Retrospective

Jennifer Graham
US Geological Survey, Troy, New York

Cyanotoxins affect all our Nation's water resources, from our smallest streams to our coastal waterways, and are often considered to be an emerging water-quality concern. However, occurrence of toxic cyanobacteria has been documented in the United States since the late 1800s, and the first program monitoring recreational waters was established in the 1950s. The study of cyanobacteria and associated cyanotoxins present several unique challenges. For example, 1) complex mixtures of cyanotoxins are common in mixed-assemblage cyanobacterial blooms, 2) spatiotemporal variability is characteristic of blooms, and occurrence of cyanobacteria and cyanotoxins may vary substantially within relatively short distances and periods of time, and 3) relations between spatiotemporal dynamics and environmental conditions are unique to individual systems as a result of complex interactions between biological, physicochemical, and hydrologic factors. Over the last 20 years, advances in analytical chemistry, remote sensing, genetic techniques, and *in situ* sensors have greatly enhanced our ability to study cyanotoxin occurrence and deepen our understanding of causal factors across a range of aquatic ecosystems. Despite these advances, many unanswered questions remain in part due to a changing climate and paradigm shifts in how we think about nutrient influences on cyanobacterial blooms and cyanotoxin occurrence.

A Small Success in Reducing Cyanotoxins in Small Temescal Reservoir, Oakland, California

Alex Horne

University of California, Berkeley, Berkeley, California

Cyanobacterial toxins can harm humans who accidentally ingest lake water. Temescal Reservoir (10 acres, 150-years-old, close to Oakland California) is heavily used for swimming, fishing, and shoreline recreation. It has long been eutrophic (low water clarity, algae scums). Urban runoff supplies nutrients and eutrophication reversal using sedimentation basins, limited dredging, and use of algaecides have not been fully successful. The common toxin, microcystin often exceeded USEPA guidelines in 2014–16, during the warm summer-fall when cyanobacteria are most common. Consequently, closures to the public averaged 85 days/y during the swim season. The algae are N-limited, but an experimental P-limitation technique was used involving two trivalent metal cations (Al^{+++} & La^{+++}) that immobilize phosphate. A successful reduction in algae (chlorophyll), and elimination of detectable cyanotoxins was eventually achieved by 2018. Secchi depth improved from 1.3 to 2.6 m moving the lake from a eutrophic to desirable mesotrophic state. Eight hepatotoxic microcystins tested were below detection and there were no beach closures due to cyanotoxins. Runoff is still rich in P, so more treatment will be needed soon until the proposed dredging and aeration/oxygenation is carried out. However, one (two) steps at a time).

Evolution of FlowCam for Cyanobacteria HAB Research and Monitoring

Harry Nelson[1], Justin Chaffin[2], Justin Murdock[3], and Savannah Judge[1]

[1]Yokogawa Fluid Imaging Technologies, Scarborough, Maine; [2]The Ohio State University, Put-in-Bay, Ohio; [3]Tennessee Tech University, Cookeville, Tennessee

Responding to the need for the "rapid counting, imaging and measurement of individual plankton cells…in natural populations", researchers at the Bigelow Laboratory for Ocean Sciences built the first FlowCam, an imaging particle analyzer for aquatic microbial research and monitoring in 1999. Use of the FlowCam has expanded beyond marine research to include freshwater cyanobacteria harmful algal bloom (cHAB) monitoring through the addition of phycocyanin detection and factory-installed settings to automatically differentiate cyanobacteria from other algae and detritus.

Here we present a brief evolution of the FlowCam with a focus on two case studies exemplifying how scientists use this technology for cHAB research and monitoring. In one example, we will explore how researchers at The Ohio State University's Stone Lab use the FlowCam to study cHABs in Lake Erie, as well as incubation experiments to better understand cHAB biology and bloom dynamics. In another example, we will learn how researchers at Tennessee Tech University integrate the FlowCam into a statewide cHAB monitoring program. Through each of these examples, we will consider the weaknesses of FlowCam, as well as other tools commonly paired with it when building a robust cHAB monitoring and rapid response program.

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

Interactive Session H1: Monitoring

November 20, 2020 | 14:00 – 15:30

30 Years of Water Quality Restoration in the Upper Ocklawaha Basin, Florida

Rolland Fulton
St. Johns River Water Management District, Palatka, Florida

St. Johns River Water Management District began water quality restoration in the Upper Ocklawaha basin in north central Florida around 1990 with the inception of the Surface Water Improvement and Management program. The major component of the program was acquisition and restoration of muck farmlands that had been developed on wetlands surrounding the basin lakes. Total phosphorus (TP) loading to Lakes Apopka and Griffin from adjacent restoration areas has been reduced by more than 90%. Decreases in total phosphorus concentrations in Lake Apopka discharges accounted for about 90% of the external load reductions of TP for downstream lakes Beauclair and Dora, and over 40% of the load reductions for Lake Eustis. Other projects contributing to nutrient reductions include the Lake Apopka marsh flow-way, rough fish harvesting, and Lake County Water Authority's NuRF project. TP concentrations in seven basin lakes affected by the restoration programs (Apopka, Beauclair, Carlton, Dora, Harris, Eustis, and Griffin) have decreased 32 to 77%. Similarly, chlorophyll *a* concentrations in these lakes have decreased 57 to 79%, and Secchi transparency has increased 50 to 150%. On the other hand, water quality has deteriorated in lakes Yale and Weir, which are unaffected by the basin restoration projects.

Eutrophication in a Subtropical, Hardwater Reservoir, Lake Buchanan, Texas

Alan W. Groeger[1] and David Bass[2]
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A monitoring program, which began in 1982, has shown significant indications of eutrophication in the hardwater (median February epilimnetic alkalinities of 2.79 meq/L), subtropical Lake Buchanan reservoir on the Colorado River in central Texas. Because the large watershed, which lies to the arid and semi-arid west, has undergone little change in land use or population growth, primarily the eutrophication is driven by internal loading of phosphorus and nitrogen. Over the 30-year plus record, variability in weather (extreme floods and droughts) and acute and chronic changes in salinity have added to the noise of the signal, but approximately from 2002 forward the intensity of hypolimnetic metabolism has increased, resulting in lower redox conditions, increasing sulfate reduction and dissolution of sedimentary $CaCO_3$, and late summer internal loading of NH_4^+ and phosphorus. Chlorophyll *a* and total organic carbon concentrations have increased, and harmful algal blooms have become more common.

Preliminary Analyses of Nutrient Data for Lakes and Reservoirs in Colorado for the Revision of Numeric Nutrient Criteria

Amanda Jensen[1], Michael Paul[2], Mark Fernandez[2], Tina Laidlaw[3], Dave Moon[4], and Blake Beyea[1]
[1]Colorado Department of Public Health and Environment, Water Quality Control Division, Denver, Colorado; [2]TetraTech Environmental Sciences, Durham, North Carolina; [3]US Environmental Protection Agency, Region 8, Helena, Montana; [4]US Environmental Protection Agency, Region 8, Denver, Colorado

The state of Colorado has a long history of nutrient control for lakes and reservoirs, utilizing control regulations to enact the state's narrative standard before recent development of numeric criteria. In 2012, numeric criteria were adopted for phosphorus, nitrogen and chlorophyll *a*, as well as a use sub-classification for Direct Use Water Supply (DUWS), with an implementation strategy of protecting high quality headwaters first. US Environmental Protection Agency (EPA) approved criteria and subclassification while expressing technical concerns related to confounding factors, classification, and productivity analyses and assumptions that informed the empirical models used for criteria development. With that in mind, Colorado is working to revise its adopted numeric criteria, with assistance from EPA Nutrient Scientific Technical Exchange Partnership & Support (N-STEPS) program. The goal of the project is to identify gaps in the dataset, evaluate potential classification schemes, and revise the numeric nutrient criteria for lakes and reservoirs statewide. Data presented will include preliminary results of exploratory classification schemes, stressor response analyses, and the potential influence of confounding factors.

*How to Design a Lake Monitoring Program to Identify Pollutant Sources

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Many lakes in Florida are subject to point and nonpoint source pollution, which drive water quality impairments. The contributing groundwater basins and watersheds are typically mixed-use, making it difficult to identify which external sources (*e.g.*, fertilizer, wastewater, etc.) are contributing the greatest pollutant loads based solely on routine ambient monitoring data. Ambient monitoring data are useful to assess the status and detect trends but does not extend understanding towards proportionality of external vs. internal load contributions. To identify nutrient sources and their relative magnitude and distribution, we employ advanced methods in sediment nutrient flux analysis, groundwater seepage analysis, and chemical analyses (*i.e.*, stable isotopes and wastewater tracers), which are combined with state-of-the-art statistical frameworks to investigate which sources are most strongly contributing nutrient loads to the lakes. We conduct phytoplankton community assessments to detect and quantify harmful algal blooms (HABs) and their potential influence on in-lake nutrient concentrations, while paleolimnological studies use multiple sediment indicators to infer the timing and severity of historical water quality and land-use change. The results of these methods can be used to quantify the potential beneficial impacts of lake management programs on water quality.

We will demonstrate a combination of analytical tools, using a multiple lines of evidence approach, for several hyper-eutrophic lakes in Central Florida, to highlight the benefit of adapting this type of analytical framework to aid in the design and implementation of more robust lake monitoring programs.

Interactive Session H2: Shallow Lakes

November 20, 2020 | 14:00 – 15:30

Do Management Strategies in Shallow Lakes Affect Carbon Dynamics and Burial?

James Cotner[1], Will Hobbs[2], Kyle Zimmer[3], and Brian Herwig[4]

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Shallow lakes are typically managed to increase the frequency of the clear-macrophyte dominated state relative to the turbid-phytoplankton dominated state. The burial of organic carbon (OC) in shallow lakes typically is much higher than rates than other inland waters. Here we explore the factors that control modern OC burial across 68 shallow lakes spanning agricultural, forested and urban landscapes. We find rates of OC burial that rank among the highest published for inland waters. We test the explanatory power of 34 variables that describe the physical, chemical and biological characteristics of these lakes. The study lakes span an ecological gradient from turbid-water phytoplankton-dominated to a clear-water macrophyte-dominated state. We ultimately find that rates of OC burial do not differ between clear and turbid lakes across different landscapes. The single-most important variable in predicting modern OC burial in shallow lakes is oxygen exposure time in surface sediments. The most parsimonious explanatory parameters of OC burial vary with landscape setting and include: macrophyte biomass, fish biomass, lake water ammonium, oxygen exposure time and lake physical setting (agricultural land use and lake depth).

Atmospheric Influences on a Shallow Seepage Lake in the North Carolina Coastal Plain: A Management Conundrum?

Diane Lauritsen

LIMNOSCIENCES, Mount Pleasant, South Carolina

Because lakes are complex systems, finding the answers to the question of why they are changing is not a simple task. Ideally, we look at hydrology first, then investigate nutrient sources. In the case of shallow seepage lakes, where precipitation on the lake surface is the primary water source, it is critical to measure atmospheric deposition of nutrients. White Lake, a shallow (mean depth 1.9 m) 432-hectare clearwater lake is fed by precipitation (> 90%) and surficial aquifer groundwater. It has historically been an acidic (pH < 5) benthic-dominated system, with low planktonic biomass. Monitoring data from a nearby National Atmospheric Deposition Program station showed a trend of increasing rainfall pH over the past 15 years, as well as a strong increase in ammonium deposition. Lake pH and TN concentrations have also increased over this period, while TP is similar to historical values. As a result, TN/TP mass ratios have increased from 12 (in 1974) to 30 (in 2020). Rainfall sampling from February – April 2020 found both inorganic and organic N, with NH_4^+ the predominant form of TIN, and the mean rainfall TN/TP (mass) was 27. A wet and stormy winter resulted in a diffuse and bioavailable nutrient source for phytoplankton, and a variety of small unicellular forms responded quickly, but moderately, suggesting that they are better competitors for nutrients under such conditions. Is it possible that natural ecosystem resilience could be considered as a management tool in situations where external nutrient sources are non-controllable?

Annual and Decadal Plant Community Dynamics in a Shallow, Eutrophic System: Shaokotan Lake, Minnesota

Donna Perleberg
Minnesota Department of Natural Resources, Brainerd, Minnesota

This project assessed the plant communities of Shaokotan Lake, in the prairie pothole region of southwest Minnesota. This shallow lake is the headwater of an agricultural dominated watershed and high nutrient inputs have led to high algal growth, high turbidity, and low plant occurrence. In the last 20 years, watershed restoration efforts have reduced in-lake phosphorus and algal blooms with resulting increased water transparency and plant growth. Submerged plant occurrence and species composition are important indicators of lake light conditions and may be predicting of an overall shift from a clear to turbid phase.

Between 2000 and 2011, plant growth was restricted to depths less than 2 meters and lakewide plant occurrence ranged from 5–30%. By 2015, plant occurrence rates reached 100% and very abundant growth was sustained until 2018 and 2019, when plant occurrence declined to 75%.

Over the last century, submerged species that have been consistently reported are turbidity tolerant species such as sago pondweed (*Stuckenia pectinata*) and coontail (*Ceratophyllum demersum*). Species that require higher water clarity were not commonly reported until 2015 when muskgrass (*Chara spp.*) was observed in 50% of shallow water sites and northern watermilfoil (*Myriophyllum sibiricum*) was found with a lakewide occurrence of 60%. Both of these species have recently declined while turbidity tolerant species remain dominant.

Non-indigenous plants have not been documented in this lake and Shaokotan provides a unique opportunity for long-term monitoring of native plant community dynamics.

*Implications of Management Actions (Land-Use Changes and Vegetation Removal) on Condition Shifts

Alicia Skolte[1], Casey Schoenebeck[2], and Andrew Hafs[1]
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Management actions have been known to lead to condition shifts within lakes, and shallow lakes are especially vulnerable to these shifts. Ecosystem conditions exist as a continuum between turbid, algal-dominated and clear, macrophyte-dominated conditions. Lake Shaokatan, a shallow Southwestern Minnesota lake, has undergone a shift throughout the early 21st century towards a clear condition in correspondence with land-use changes. These land-use changes were accomplished through the rehabilitation of three feedlots, four wetland areas, and shoreline septic systems. A recent algal bloom in the summer of 2019, suggesting a shift towards a turbid condition, may have been initiated by the chemical removal of about 15 percent surface area of vegetation within the lake basin. The primary objective of this study examined the long-term trends of water quality, percent phytoplankton composition, zooplankton and fish relative biomass, as well as percent coverage of the littoral area by plants on Lake Shaokatan. This study also documented how two management actions (land-use changes and chemical removal of vegetation) had a role in ecosystem shifts. The final objective investigated whether patterns of phosphorus concentrations, plant presence, or phytoplankton taxa correlated with trophic level changes and/or served as indicators, along with taxon of plants or phytoplankton, of an oncoming shift in the ecosystem. Results of this study will aid management agencies to make deliberate decisions and inform them of triggers for a condition shift.

General Sessions

General Session 1A: HABs

November 17, 2020 | 11:00 – 12:00

*Phytoplankton Assemblages in Selected Freshwaters of New Jersey

Yaritza Acosta Caraballo and Meiyin Wu
Montclair State University, Montclair New Jersey

New Jersey freshwater phytoplankton assemblages are poorly known and there is no list of freshwater phytoplankton taxa in the state. This study seeks to describe phytoplankton assemblages, their distribution and abundance in freshwaters of New Jersey. The objective of this study extends to identify potential toxin producing cyanobacteria taxa. A total of 60 fresh waterbodies were used for this study. Microcystins were analyzed from 31 samples using EPA Method 546. Water chemistry parameters were recorded *in situ* using the YSI multi parameter sonde. A total of 65 taxa of freshwater phytoplankton were documented. Cyanobacteria species are present in 75% of the waterbodies examined in this study, with an average dominance of 45%. The presence of taxa capable of producing multiple toxins, such as *Anabaena spp.*, infers the difficulty of management and treatment as well as increased public health risks. Among the 31 collected water samples, two (6%) were found to have Microcystins concentrations above the recreational advisory guidance value. Water characteristic results showed a weak linear correlation between total and cyanobacterial cell densities and environmental variables such as dissolved oxygen, temperature and chlorophyll *a*. The results of this study will help address public health, economic and environmental threats related to harmful algal blooms in New Jersey.

Laboratory Evaluation of Algaecide Effectiveness for Control of Microcystin-Producing Cyanobacteria at a Large Scale – Okeechobee Waterway

Ciera Kinley-Baird[1], Alyssa Calomeni[2], David Berthold[3], Forrest Lefler[3], Maximiliano Barbosa[3], John H. Rodgers[4], and H. Dail Laughinghouse IV[3]
[1]Aquatic Control, Inc., Seymour, Indiana; [2]EA Engineering, Science, and Technology, Inc., PBC, Hunt Valley, Maryland; [3]Agronomy Department, University of Florida/IFAS, Davie, Florida; [4]Clemson University, Clemson, South Carolina

To manage HABs at large scales, multiple tactics including monitoring, prevention and mitigation are necessary. Algaecide applications meet decision-making criteria required by water resource managers (effective, scalable, selective), but have not yet been evaluated at a large scale within the Okeechobee Waterway. This study was conducted to bolster the database for tactics against microcystin-producing cyanobacteria in large aquatic systems. Laboratory evaluations are the critical first step for minimizing uncertainty at larger scales and improving confidence in decision making. The objectives were to 1) collect samples containing microcystin-producing cyanobacteria from the Okeechobee Waterway, 2) measure responses of cyanobacteria to algaecides, 3) measure the extent of microcystin release and degradation and 5) rank the algaecides based on management priorities. The microcystin-producing cyanobacteria consisted of *Microcystis aeruginosa* and *Pseudanabaena sp*. Cyanobacteria were sensitive to GreenClean® Liquid 5.0 applied individually and in combination with Hydrothol® 191 as well as several copper-based formulations. Exposures of Algimycin® PWF (0.63 mg Cu/L), Argos (0.70 mg Cu/L), Cutrine® Ultra (0.71 mg Cu/L), and Captain® XTR (0.74 mg Cu/L) resulted in the least extent of microcystin release 24-h after algaecide exposures. Average total microcystin concentrations decreased from 547 μg/L in untreated controls to less than 10 μg/L for all treatments by 9-d after exposure, with the exception of GreenClean® Liquid 5.0. Algaecide formulations were ranked based on whether management priorities were focused on effectiveness alone, and effectiveness with minimized microcystin release and persistence. Results from this study provide critical comparative performance data necessary for designing and implementing demonstration studies prior to full-scale treatments.

Preliminary Analyses of Continuous Water Quality Data From Sensors Deployed at Harmful Cyanobacterial Bloom Monitoring Stations

Sabina Perkins, Jennifer Graham, and Guy Foster
US Geological Survey New York Water Science Center, Troy, New York

Harmful Cyanobacteria blooms (HCBs) are of growing concern in the Finger Lakes region of upstate New York. The US Geological Survey, in cooperation with the New York State Department of Environmental Conservation, has developed advanced, multi-depth water-quality monitoring stations (floating platforms) to better understand the environmental conditions contributing to cyanobacteria blooms. The study is currently taking place in three Finger Lakes of varying trophic states that experience HCBs: Seneca Lake, Owasco Lake, and Skaneateles Lake. A preliminary analysis of the continuous water-quality data collected thus far at these stations will be presented. Continuous water quality sensors have revealed a dynamic aquatic environment that includes internal seiches at all three lakes. Temperatures at a single depth can swing up to 13 degrees Celsius within a half-hour in the middle of the water column at Seneca Lake. During extreme wind events, on the north end of the lake where the platforms are located, epilimnetic water can extend from the surface down to 100 ft. These extremely dynamic shifts in light availability, water parcel location in the lake, and possibly pressure raise questions about the conditions experienced by plankton communities in these lakes.

*Thermal Stratification at Chautauqua Lake (New York): Implications for Internal Phosphorus Loading

MaryAnn Mason and Courtney R. Wigdahl-Perry
State University of New York at Fredonia, Fredonia, New York

Lake stratification, or separation of water layers based on their temperature and density differences, can impact dissolved oxygen levels, nutrient concentrations, algae growth, and other ecological processes within lake ecosystems. At Chautauqua Lake (Chautauqua County, New York), a eutrophic lake with frequent and persistent harmful algal blooms (HABs), past monitoring datasets have indicated that stratification is likely weak and/or unstable. However, additional information is needed to fully characterize stratification patterns and understand how this may influence internal phosphorus loading and HABs at this site.

In the summer of 2019, we performed weekly vertical profiles and deployed high-frequency temperature sensors to improve spatial and temporal perspectives on the internal temperature dynamics at Chautauqua Lake. In contrast to past years, we found strong, stable stratification that lasted from late June through late August/early September. Oxygen depletion in the deep layer occurred rapidly after stratification onset and persisted until the lake turned over. High-frequency temperature sensors also indicated daily vertical movement of the thermocline (up to 4 m vertical displacement over a 24 hr period), and a comparison of simultaneous data from two different locations within the lake suggested an internal seiche wave as a potential cause. The combination of strong stratification, anoxia, and internal seiche action may lead to phosphorus release from sediments and contribute to rapid cyanobacteria growth. Understanding these processes will help local resource managers target effective management actions to reduce internal phosphorus loading and HABs in the future.

General Session 1B: National Lakes Assessment

November 17, 2020 | 11:00 – 12:00

2017 National Lake Assessment Survey Results for Minnesota Lakes

Allison Gamble, Jesse Anderson, and Lee Engel
Minnesota Pollution Control Agency, Saint Paul, Minnesota

We present Minnesota surface water quality results from the 2017 National Lake Assessment Survey, compare results between the three main ecoregions in the state and discuss similarities and differences from previous National Lake Assessment surveys. In 2017, the Minnesota Pollution Control Agency's Water Quality Monitoring Unit and partners sampled 155 lakes, equally distributed over the state's three major ecoregions, as part of the nation-wide US Environmental Protection Agency's National Lake Assessment. Fifty of the sampled lakes were part of the US Environmental Protection Agency's initial selection of lakes, but Minnesota was unique in the nation in augmenting the survey with 100 additional lakes, producing a minimum of 50 sampled lakes per major ecoregion in the state. Lakes sampled in 2017 ranged in size from small (less than 10 acres) to 1,835 acres. The main differences were driven by differences in location, as has been documented in past National Lake Assessment surveys and historical Minnesota Pollution Control Agency lake monitoring databases. Lakes in the northeastern part of the state tended to have the lowest nutrient levels and highest lake clarity, while lakes in the southwest part of the state tended to have the highest nutrient levels and lowest lake clarity. Overall, the National Lake Assessment datasets indicated that one-time visits were useful proxies of the trophic state of both lakes statewide and by ecoregion.

Leveraging the National Lakes Assessment to Classify and Evaluate the Condition of Wisconsin's Macrophyte Communities

Catherine Hein[1], Justin Poinsatte[2], Alison Mikulyuk[1], and Michaela Kromrey[1]
[1]Wisconsin Department of Natural Resources, Madison, Wisconsin; [2]Southeastern Wisconsin Regional Planning Commission, Waukesha, Wisconsin

The US EPA National Lakes Assessment provides an opportunity for states to evaluate lake condition at the population scale. In 2017, Wisconsin obtained its first probabilistic survey of macrophyte communities in lakes across the state. In addition to finding that most Wisconsin lakes are in good condition according to two macrophyte bioindicators, this survey better defined macrophyte communities across the state, particularly in small lakes often overlooked by management. The Submersed Cosmopolitan community was dominated by elodeid species and is associated with nutrient-rich alkaline waters. The Mixed Characid, composed of mixed elodeid and Characean species, was the most species rich community and occurred in nutrient-poor alkaline waters. Soft water lakes were largely split between the clear-water Isoetid Meadows, the highly stained Floating-leaf Glades, and the stained and highly acidic Moss-dominated community. Lakes are often classified in terms of hydrology and trophic status, but not in terms of their macrophyte communities. These results will hopefully inform conservation and protection efforts that can be tailored to the unique macrophyte communities found in Wisconsin lakes.

*National Lake Assessment for Indiana and the United States – 2017

Sarah LaVoy and Sarah Powers
O'Neill School of Public and Environmental Affairs, Indiana University, Bloomington, Indiana

The National Lakes Assessment (NLA) is part of EPA's National Aquatic Resource Surveys, which are a collaborative program between the EPA, states, and native tribes to assess the quality of the nation's coastal waters, lakes and reservoirs, rivers and streams, and wetlands using a statistical survey design. Indiana expanded on the NLA to statistically survey the condition of the state's lakes, ponds, and reservoirs. This presentation is designed to address four primary questions: 1) What is the condition of Indiana Lakes? 2) What are the key problems? 3) How widespread are the problems? 4) How does the NLA compare with Indiana statewide monitoring programs. This talk will introduce you to the NLA design, results from 2007, 2012, and 2017 and what story the data tells for the state of Indiana's Lakes. Looking forward, the National Lakes Assessment will improve the knowledge and understanding of the stressors that impact our waterbodies.

General Session 1C: Monitoring (Citizen Science)

November 17, 2020 | 11:00 – 12:00

#Cloud Services: Help for Lake Associations

Art Dunham
Vital Volunteers Inc., Arden, Ontario, Canada

Many lake associations are using spreadsheets to track member information, finances and lake monitoring data. The data is stored on an executive's home computer limiting access to the board. Moving data to the cloud enables all executives to have real-time access and workload sharing as any executive can update the information.

Cloud services can automate many of the function's lake associations are doing manually today. Tracking member dues and donations is a great example. Typically, a member fills out a membership form and mails a check, requiring manual effort by both their membership executive and their treasurer. Utilizing cloud services, a member fills in their contact information online, pays their dues / donation online and automatically their member record is created / updated, an email receipt is sent, and a finance record is created. No effort required by the membership executive or the treasurer. Other opportunities are website updates, surveys, tracking project actions, water quality monitoring, email communication, document management, online maps (monitoring sites, buoys, spawning beds), septic survey, BioBlitz. Less administration time means more time doing environmental work and education.

Note the author of this abstract has a financial interest with Vital Volunteers who provides cloud services to community associations HOWEVER Vital Volunteers or its services will not be referenced as part of this presentation other than the link of the author to the company. The presentation will be generic identifying types of services available and the benefits.

#Smart Citizen Science – Monitoring Lake Erie's Watersheds With Volunteers and New Technology

Max Herzog
Cleveland Water Alliance, Cleveland, Ohio

The Lake Erie iteration of Great Lakes One Water (GLOW), a collaboration between community foundations across the Great Lakes Region, is focused on enabling Smart Citizen Science. Our collective aim is to position Lake Erie and its communities as a trailblazer in community-led solutions for water monitoring by embracing new technology and data that are trusted, transparent, and tied to regional policy and education. The effort will launch in seven targeted communities represented by our Lake Erie Basin community foundations and be led at the regional level by Cleveland Water Alliance (CWA).

The initial rollout of the program will focus on synthesizing existing citizen science, new technology, and strategic communications into a highly coordinated regional monitoring network for nutrient pollution. The effort will be driven at the local level through investments in "Smart Citizen Science Hubs," existing citizen science organizations with deep roots in their local community.

#Power to the People: Using Citizen Science to Detect Water Clarity Trends in Minnesota's Lakes and Streams

Shannon Martin and Laurie Sovell
Minnesota Pollution Control Agency, St. Paul, Minnesota

For over 45 years, the Minnesota Pollution Control Agency has supported volunteers in collecting water clarity data through its Citizen Lake and Stream Monitoring Programs (CMP). Citizen-collected data is directly used in Minnesota's formal water quality assessment process – a testament to the value the MPCA places on volunteers' ability to accurately collect data. However, the real power of the program lies in the sheer magnitude of data collected by both short- and long-term volunteers over decades. These datasets are the driving force behind the CMP's ability to conduct trend analyses on thousands of waterbodies across the state. Using the open source statistical program R, the CMP annually updates lake and stream clarity trend results and shares them with the public and water resource practitioners alike. Through the Citizen Lake and Stream Monitoring Programs, the MPCA broadens its understanding of water health in the state while directly supporting local water advocates interested in protecting Minnesota's lakes and streams. In this presentation we will share information about the data volunteers collect, statistical analyses used to detect trends in water clarity, and how the MPCA uses and shares trend results.

#Trends in New Hampshire's Water Quality

Kirsten Nelson and Dave Neils
New Hampshire Department of Environmental Services, Concord, New Hampshire

New Hampshire is home to over 1,000 lakes and ponds, and the economic contribution of swimming, fishing, and boating brings in hundreds of thousands of dollars to the Granite State each year. While New Hampshire's waterbodies are much loved, there is potential that they might be loved to death, which would have economic as well as ecological effects. Land use, impervious surfaces, nutrient loads, and climate change all have the potential to alter New Hampshire's water quality. In a first-of-its-kind report, NHDES summarized percentiles, long-term trends, and short-term changes of several water quality parameters from 150 lakes and ponds that participate in the Volunteer Lake Assessment Program (VLAP). Water quality data are collected on VLAP waterbodies annually, building long-term datasets that track changes over time. Waterbodies with ten or more years of data were examined for changes in water quality parameters such as chlorophyll *a* concentration, Secchi depth, specific conductance, and total phosphorus, among others.

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

Chris Adams[1], Alyssa Anderson[2], Lisa Borre[3], Julie Chambers[1], Kenneth Chiu[4], Michael Forcella[5], Philip Forsberg[6], Kayla Gower[7], Alex Heppner[7], Ryan Jorgensen[7], Mark LeBaron[7], Steve Lundt[8], Maggie Reilly[9], Perry Thomas[10], and Kathleen C. Weathers[5]
[1]Oklahoma Water Resources Board, Oklahoma City, Oklahoma; [2]North American Lake Management Society, Madison, Wisconsin; [3]Cary Institute of Ecosystem Studies, Annapolis, Maryland; [4]Binghamton University, Binghamton, New York; [5]Cary Institute of Ecosystem Studies, Millbrook, New York; [6]North American Lake Management Society, Colorado Springs, Colorado; [7]Gold Systems, Salt Lake City, Utah; [8]Metro Wastewater Reclamation District, Denver, Colorado; [9]North American Lake Management Society, Burlington, Vermont; [10]North American Lake Management Society, Frankfort, Kentucky

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) 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 (GLEON) Lake Observer mobile app for project partners and the AWQMS community. The overall goal is to provide a long-term solution for Secchi Dip-In data management, validation, sharing, and flow to the US government's Water Quality Exchange (WQX), and ultimately the Water Quality Portal (WQP). The project is now underway and already producing new tools for data submission and management via AWQMS and the Lake Observer app, including web-based data entry forms and data visualization tools, spreadsheet templates for formatting data for bulk data upload feature and database connections with the Lake Observer app. AWQMS was modified to allow individual citizen scientists to upload or enter their results while automatically consolidating all data submissions under a single NALMS organization for submission to WQX and the Water Quality Portal. The new data entry system was used for the Dip-In event this year. NALMS is also conducting a pilot test in Kentucky to complete a bulk upload of historical data and setting up an import configuration for new data going forward. Project partners will present an update of the collaboration to date, provide a demo of the new data submission and visualization tools, and share results from the past three years. This collaboration supports an expanded Secchi Dip-In and increases the amount of water quality monitoring data that are publicly available via WQX and WQP.

#Winter LakeKeepers – A Citizen Science Approach to Collecting Winter Lake Data in Collaboration With Anglers and Lake Stewards in Alberta

Caleb Sinn and Bradley Peter
Alberta Lake Management Society, Edmonton, Alberta, Canada

As interest in winter limnology is growing, finding creative means of collecting winter lake data is becoming a necessity. Winter lake conditions can highlight the impacts of climate change, may forecast open-water conditions, and provide insight into the quality of fish habitat. In 2019, the Alberta Lake Management Society (ALMS) piloted a citizen science winter lake monitoring program, Winter LakeKeepers, through collaboration with anglers. Monitoring kits, including a YSI ProODO probe, were assembled, and training documents, field sheets, and safety materials, were developed. The program successfully engaged anglers and stewards who were enthusiastic about collecting winter water-quality data. In 2019, ten lakes were monitored at one location once through the ice-on period. In 2020, the program was enhanced with increased sampling effort (22 waterbodies) and a focus was placed on collecting multiple samples throughout the ice-on period from individual lakes. Data gathered included total phosphorus (TP), water temperature, dissolved oxygen (DO), and supplementary environmental observations. Data was shared through a water quality report, and raw data were uploaded through the Gordon Foundation DataStream. As Winter LakeKeepers continues to gain traction, the data from the program has the potential to improve understanding of year-round lake dynamics and inform fisheries managers' decision making. In future years, ALMS is looking to include additional parameters that may have further utility in forecasting the open-water season conditions, as well as developing knowledge about under-ice lake ecology.

General Session 1D: Aquatic Invasive Species Risk and Prevention

November 17, 2020 | 11:00 – 12:00

A Basin-Wide Approach to Invasive Species Management: The Upper Columbia Conservation Commission

Lori Curtis[1] and Tom Woolf[2]
[1]Whitefish Lake Institute, Whitefish, Montana; [2]Montana Fish, Wildlife & Parks, Helena, Montana

Created by the 2017 Montana Legislature in response to the 2016 mussel detection, the Upper Columbia Conservation Commission (UC3) exists to protect the aquatic environment in Montana tributaries to the Columbia River from the threat of AIS in order to protect water resources, downstream interests, and the economic and ecological vitality of the region. The UC3 provides an assembly in which to discuss, debate, coordinate, plan and implement aquatic invasive species programming for the Montana portion of the Upper Columbia Basin across international borders, on tribal lands, regionally, statewide, and locally. Increased coordination with water management agencies within the Columbia River Basin in Montana, as well as provincial and state partners in the basin has been both affirming and encouraging, but it is a great responsibility and the UC3 continues evolving as an organization. Focusing on education and outreach, early detection monitoring, watercraft inspections, and response and preparedness, the UC3 is a 14-person commission with 11 *ex officio* members. This presentation will address the challenges and successes of coordinating across state, regional, and country borders; and the diverse organizations and people responsible for doing this work. We will highlight success stories from partners including a citizen science organization; Montana conservation districts; an independent municipality; and Montana Fish, Wildlife & Parks—the resource management agency responsible for AIS programming in the state.

*Watercraft Inspection and Decontamination Programs

Quagga D. Davis
Quagga D LLC, Henderson, Nevada

The expansion of inspection programs has increased the need to have trained inspection and decontamination program staff and managers regionally adopt protocols and standards to guide uniformity to the procedures and language amongst the state/agency programs.

To serve these needs, Pacific States Marine Fisheries Commission began the Watercraft Inspection Training (WIT) program in 2006. Quagga D has been on contract for Pacific States Marine Fisheries Commission's Aquatic Invasive Species program since 2008, educating the AIS Industry for the 19 Western States and several Canadian Provinces.

The purpose is to teach natural resource personnel watercraft inspection and decontamination techniques and methods utilizing the "Uniform Minimum Protocols and Standards for Watercraft Interception Programs for Dreissenid Mussels in the Western United States."

The trainings utilize WIT training manuals by the Western Regional Panel (WRP) on Aquatic Invasive Species' WIDT committee. These trainings have proven critical, as properly decontaminating fouled watercraft using current standards is an arduous task, and resource agencies need to be able to trust the decontaminations and inspections conducted by other jurisdictions.

The program has expanded since inception. Trainer Training (WIT III) began April 2015, these individuals have trained seasonal and fulltime staff in their respective programs. Advanced Decontamination was added in 2017 and cover advanced skills and knowledge more complex systems, what the triggers are for decontamination and the importance of standardizing protocols.

The author of this abstract has/have a financial interest in the training as described.

Online Boater Led Check-In/Check-Out Alternative to In-Person Inspections: A COVID-19 Response Pilot

Edgar Rudberg

CD3, General Benefit Corporation, Saint Paul, Minnesota

Due to the high cost of high pressure, heated water decontamination, reducing the spread of aquatic invasive species (AIS) often relies upon the adoption of best management practices at the individual level. This is especially needed during a pandemic. This presentation will outline a pilot project in Minnesota in adopting a digital alternative to in-person inspections. In addition, the presentation will go over the biological efficacy for doing so.

The author of this abstract has a financial interest in the corporation, commercial products, and methods described.

*Lakefront Property Owner Risk Concepts and Lake Aquatic Invasive Species Status: Insights From Qualitative Interviews and Parcel Analysis

Theresa Vander Woude, Bret Shaw, and Dominique Brossard

University of Wisconsin-Madison, Madison, Wisconsin

This study identified some relevant risk concepts that a sample of Wisconsin lakefront property owners hold about aquatic invasive plants and treatment methods, including chemical applications. Sets of similar lakes were chosen in five regions and publicly-available phone numbers were dialed for a randomly-selected parcel on each lake until a participant was found, for thirteen total interviews conducted covering six themes related to risk perception and invasive plants.

While findings should not be generalized to all lakefront property owners, some interesting relevant concepts were identified. Respondents cited a range of risks of AIS, especially risk to fish/fishing, along with risks to recreation such as swimming and boating, human, pet and ecosystem health, water quality and property values. Many saw AIS as a public problem and therefore public responsibility, and the topic prompted emotional reactions in some respondents, who expressed feelings of anger or helplessness, and some wished to be able to take drastic actions. Respondents' willingness to follow a "slower approach" advocated by experts appeared to compete with a desire to take some action right away. In comparing parcel data for property owners by lake AIS status, the study also found interesting descriptive trends: for example, while the majority of Wisconsin lakes do not have AIS, a significant majority of lakefront parcels are situated on lakes with established AIS populations. Furthermore, these lakes are very different in average property values and number of parcels. For the majority of Wisconsin lakefront property owners, living with invasive species is the norm.

General Session 1E: Remote Sensing

November 17, 2020 | 11:00 – 12:00

Informing Lake Management Using *In situ* and Satellite Remote Sensing Techniques

Brian Beck[1], Kailey Cermak[1], Leif Olmanson[2], Ben Page[2], Jill Sweet[1], Tom Langer[1], and Anna Brown[1]
[1]Minnehaha Creek Watershed District, Minnetonka, Minnesota; [2]University of Minnesota, St. Paul, Minnesota

In 2013, Minnehaha Creek Watershed District completed a diagnostic study in the Six Mile Creek minor subwatershed, which included a variety of deep and shallow lakes. The study identified several drivers of poor water quality and biological conditions, which included stormwater runoff, overabundance of common carp, degraded wetlands, and in-lake sediment release of phosphorus. MCWD has invested substantially in the restoration of the Six Mile Creek Subwatershed, which has resulted in water quality and biological improvements in a subset of lakes. For example, Wassermann Lake achieved several interim goals such as carp reduction, watershed phosphorus load reductions, and upstream wetland restoration. Therefore, internal phosphorus loading from sediment is the remaining phosphorus load reduction necessary to meet goals in Wassermann Lake.

It is important to note, watershed load reductions and carp management are only tactics in the larger strategy to improve Wassermann Lake ecological conditions. MCWD staff identified the information needed to characterize recent water quality improvements and inform internal load management in Wassermann Lake. The two primary data gaps include improving the temporal and spatial resolution of thermal stratification and characterizing water clarity improvements from past project implementation.

District staff identified two remote sensing methodologies including continuous *in situ* data loggers to characterize lake stratification and water clarity data from satellite imagery to characterize the spatial improvements throughout Wassermann Lake due to management activities. The results of the remote sensing approaches will be compared to traditional discrete data to show the value of remote sensing's ability to inform management activities.

Sensor-Based Approaches for Harmful Algal Blooms

Guy Foster
US Geological Survey New York Water Science Center, Troy, New York

The US Geological Survey (USGS) has employed a variety of sensors to detect, monitor, characterize and map harmful algal blooms (HABs) in several types of aquatic ecosystems across the nation. *In situ* sensors that measure pH, dissolved oxygen, and the fluorescence response of algal pigments (such as chlorophyll, phycocyanin, and phycoerythrin) have been successfully deployed on both stationary and moving platforms to characterize HABs. Water-quality sensors are increasingly being operated in conjunction with Geographic Positioning Systems (GPS) and cameras (local, aerial, and satellite) to produce spatially dense maps of water-quality conditions related to HABs. When coupled with discrete sample data, water-quality sensors can potentially provide real-time model inputs allowing for near-term HAB prediction and forecasting. This talk will give an overview of these efforts, discuss water-quality sensor responses to HABs, and touch on the benefits and challenges of modeling and mapping HABs.

Effect of Diminishing Snow Cover on the Desiccation of Terminal Lakes in the Western US Using Remote Sensing: Great Salt Lake and Mono Lake

Dorothy Hall[1], George Riggs[2], Nicolo DiGirolamo[2], and Donal O'Leary[1]
[1]University of Maryland, College Park, Maryland; [2]SSAI, Lanham, Maryland

The viability of terminal lakes in the western United States has been threatened by consumptive water use and climate change. The Great Salt Lake (GSL) in Utah and Mono Lake (ML) in California have been adversely affected by upstream water diversions since 1847 and 1940, respectively. Because of recent efforts to control stream diversions, there has been an improvement in the health of Mono Lake, allowing the lake level to increase somewhat and salinity to decrease. This has not been the case with the GSL. We use MODerate-resolution Imaging Spectroradiometer (MODIS) and Visible Infrared Imaging Radiometer Suite (VIIRS) satellite data products to study interannual changes and 20-year trends in snow cover, air and surface temperature and evaporation in the GSL basin and in Mono Lake Basin (MLB). When streamflow is dominated by snowmelt, changes in lake levels vary interannually with amount of snow cover in the basin, as determined from MODIS and VIIRS cloud-gap filled (CGF) snow-cover and snowmelt-timing maps of the GSL basin and MLB. In the GSL basin, air and surface temperatures, and evaporation, have increased and snowmelt-timing maps, derived from a new MODIS Terra standard snow-cover product, show that snow is melting ~9.5 days earlier compared to when the MODIS record began in 2000, resulting in less streamflow into the lake and a reduction in the lake levels. The ongoing threat of drought conditions is a key factor in the recovery of Mono Lake, and in the rate of desiccation of the GSL.

Assessment of Remote Sensing for Hydropower Projects in the US

Carly Hansen, Chris DeRolph, and Paul Matson
Oak Ridge National Laboratory, Oak Ridge, Tennessee

As owners and operators of hydropower dams move towards more sustainable management of reservoirs, it is increasingly important to be able to evaluate the impoundment, dam, and river as parts of a single, more comprehensive system. Issues such as greenhouse gas emissions, algal blooms, and sediment in a reservoir translate to concerns downstream, including interactions with in-stream vegetation, dissolved oxygen, suspended sediment, and other water quality/clarity issues. Readily available satellite and aerial imagery has a long history of use in coastal areas and inland lakes, however their use in river systems is relatively limited due to coarse spatial resolution. We evaluate remote sensing data and its suitability for use in evaluating water quality concerns of hydropower systems (*i.e.*, reservoirs and rivers downstream of the impoundment) at various scales and address foundational research questions: What are the characteristics of hydropower systems (number and type of facilities, conditions of reservoirs and rivers, etc.) that can be assessed using medium resolution data? Which systems will require increased image resolution (*e.g.*, from UAV platforms)? How can other remote sensing -derived data products support holistic evaluations of hydropower systems? This assessment of current data availability and the future needs will aid in developing sustainable hydropower management strategies and enable coordination between energy and environmental/resource protection stakeholders.

Low Cost, Networked Sensor Buoys for High Resolution Spatial and Temporal Detection of Harmful Algal Blooms in Lakes

Christopher Lee[1], Kara Wolley[1], Lauren Knose[2], and Craig Williamson[2]
[1]AquaRealTime, Boulder, Colorado; [2]Miami University, Oxford, Ohio

Despite innovations in monitoring harmful algae blooms (HABs), existing technologies lack sufficient temporal and/or spatial resolution to adequately inform HAB research and mitigation efforts. Current technologies either provide insufficient resolution to inform local decisions or are too expensive and burdensome to deploy at the scale necessary to satisfactorily detect and monitor HABs. Manual sampling efforts are limited because algal blooms can develop suddenly and in a patchwork of scattered locations.

We have developed a technology wherein networked, lightweight, low cost sensor buoys can be rapidly deployed to multiple locations in a lake and report real time data autonomously. Each buoy measures levels of cyanobacteria and other groups of algae from the fluorescence of their photosynthetic pigments. Data are streamed to a dashboard displaying levels of chlorophyll, phycocyanin, turbidity and water temperature. Automated alerts are given when levels exceed a set threshold.

This presentation will provide:

- A review of fluorescence-based HAB sensing for lake management

- A description of the technology, including benefits and limitations

- A review of results from field studies

- A discussion of upcoming work on the use of machine learning to improve the interpretation of networked data sources.

The technology is currently being studied in trials in Colorado, California, Indiana, Massachusetts, and Wisconsin. By November 2020, units will be deployed at fifteen sites in private and public lakes, with further locations including Ohio, New York, Utah, Pennsylvania, and Florida. Measurements from the technology will be compared to manual samples and data from co-located 3rd party sensors at the same locations.

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

General Session 1F: TMDL/Nutrient Loading

November 17, 2020 | 11:00 – 12:00

Minnehaha Creek Bacteria Source Identification Study

Shahram Missaghi[1] and Nico Cantarero[2]
[1]City of Minneapolis, Minneapolis, Minnesota; [2]Wenck , Minneapolis, Minnesota

Minnehaha Creek is a 22-mile long urban stream in Hennepin County, Minnesota that flows east from Lake Minnetonka to the Mississippi River through the southwestern Twin Cities area. An approximately six-mile reach of Minnehaha Creek runs through the jurisdictional boundaries of the City of Minneapolis. Water-quality monitoring data indicate that water-quality standards for recreational uses are not being attained in Minnehaha Creek, based on exceedances of numeric criteria for *Escherichia coli* (*E. coli*), which is a common fecal indictor bacteria. As a result of the impairment, a total maximum daily load (TMDL) has been established for the creek and requires that *E. coli* levels be reduced. In response to the TMDL, the City's Public Works Department initiated the Minnehaha Creek Bacterial Source Identification Study to identify the sources of *E. coli* in Minnehaha Creek and the surrounding watershed within the City's jurisdiction.

This Study used a weight of evidence approach to address several Study questions during both dry weather (at least 48 hours after a storm event) and wet weather (during a storm event). It was organized to focus on several primary Study elements first, followed by special studies based on the initial results.

Dry Weather Study Elements

- Baseline Monitoring

- Sanitary Survey Investigation

- Groundwater Assessment

- Lake Hiawatha Assessment

- Bacterial Regrowth Assessment

- Sediment Special Study

- Street Debris Special Study

- Biofilm Resuspension Special Study

Wet Weather Study Elements

- Baseline Monitoring

- Pollutograph Monitoring

- Apron Outfall Assessment

- Grit Chamber Special Study

- *E. coli* Genetic Diversity Index

This multiple lines of evidence approach provided a large amount of information on the sources of *E. coli* in the Study Area, the transport mechanisms that deliver the *E. coli* to Minnehaha Creek, and an estimate of the relative impact of the source on *E. coli* levels in the creek based on the flow regime.

Evaluating 20 Years of Progress Toward the TP Load Reduction Goal in the Como Lake Watershed

Joe Sellner and Britta Belden
Capitol Region Watershed District, St. Paul, Minnesota

Como Lake in St. Paul, Minnesota has been listed as impaired since 2002 for excess nutrients, namely total phosphorus (TP). The TMDL adopted for the lake set a watershed load reduction target of 60% based on TP loads modeled from year 2000. Significant investments in capital improvement projects and small-scale structural and non-structural BMPs have been made in the Como watershed since 2000. With the development of a new lake management plan in 2019, the Capitol Region Watershed District (CRWD) evaluated the progress made toward the TP load reduction goal. To estimate the current progress, a P8 urban catchment model was developed and calibrated with collected flow and water quality monitoring data. By running the model under two scenarios, year 2000 baseline conditions and 2018 conditions, CRWD determined that an annual watershed load reduction of 20% has been achieved. The modeling effort, which took treatment train effects and net load to Como Lake into account, identified subwatersheds currently receiving little or no treatment and others that may be over treated. The results were used to identify priority areas for treatment, identify potential BMPs, and to create a 20-year plan to reach the overall TP load reduction target of 60%. Potential BMPs to meet this goal include both structural and non-structural strategies. Future proposed BMPs can be evaluated using the model to estimate their net impact to the load reduction goal and to determine the cost-benefit of each.

General Session 1G: Salt (Management)

November 17, 2020 | 11:00 – 12:00

Minnesota's Chloride Management Plan

Brooke Asleson[1], Connie Fortin[2], and Carolyn Dindorf[2]
[1]Minnesota Pollution Control Agency, St. Paul, Minnesota; [2]Fortin Consulting, Inc., Hamel, Minnesota

Minnesota has a growing salty water problem that threatens its freshwater fish and other aquatic species. The Statewide Chloride Management Plan (CMP) outlines a comprehensive strategy to reduce salt (chloride) use from a variety of sources to protect our lakes, rivers, and other water resources. The plan was developed by the Minnesota Pollution Control Agency (MPCA) in partnership with municipalities, counties, watershed districts and other state experts. As part of this effort, the MPCA and partners collaborated to monitor, evaluate, and better understand the level of chloride in lakes, streams, wetlands, and groundwater. The main sources are road salt runoff; water softener brine that passes through in wastewater; and fertilizer, manure and dust suppressants.

The plan will help local government units, winter maintenance professionals, decision-makers, and others take action to protect Minnesota's water resources from chloride pollution. It is intended to provide a better understanding of chloride sources, trends in chloride pollution, determine goals for local reductions in salt use, detect and prioritize critical areas for reducing salt use, research strategies to reach goals, implement and measure goals and provide tools and resources for reducing salt use, including a computer tool (Smart Salting Assessment tool) to track changes in practices and salt reductions. The implementation strategy is a performance-based approach to reducing chloride which allows stakeholders and regulators flexibility in the type of BMPs and timing of implementation.

Keep Salt Out of Lakes Through Smart Salting Training

Carolyn Dindorf
Fortin Consulting Inc., Hamel, Minnesota

Minnesota, the land of 10,000 lakes, has a salt problem. Really, it's a chloride problem. Fifty of our lakes and streams exceed the federal/state standard of 230 mg/L for chloride, and another 75 are close. Road salt makes up about 42% of the salt load in Minnesota and there is no feasible way to remove chlorides once they reach our surface and groundwater. Prevention is the key. With USEPA 319 funding and assistance through the Minnesota Pollution Control agency and local partners, we developed and teach Smart Salting classes to winter maintenance professionals, water resources staff and property managers to help reduce the chloride load from winter maintenance. Four different classes are available; Smart Salting for parking lots and sidewalks, roads, property management, and level II for organizations to track their improvements in practices. The training covers the impacts of salt on our waters and best management practices to improve winter maintenance efficiency and reduce salt use. Practices are based on the science of how salt works, winter maintenance experience, and equipment and material innovation. Through the training we strive to motivate winter maintenance staff to be the best in their work and protect the waters most of them enjoy for recreation. Examples, including the Mayo Clinic, will be used to show how the training promotes adoption of these best management practices that can significantly reduce salt used for winter maintenance, helping to keep salt out of our surface and groundwater.

General Session 1H: Urban Ponds/Stormwater

November 17, 2020 | 11:00 – 12:00

*Identification and Characterization of Urban Lakes Across the Continental United States

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

Urban lakes contribute to the quality of life and sustainability in urban areas by providing a variety of ecosystems services. The main goals of this study were to define and identify urban lakes across the continental United States; to present a comprehensive assessment of water quality, management activities and the main ecosystem services provided; and determine how these systems compare to non-urban lakes. Lakes and reservoirs were identified as "urban" if completely within areas with at least 50,000 people, a sub-watershed population density of at least 1,000 people per square mile and more than 10% of impervious cover. We identified 1,950 urban lakes and reservoirs that resulted smaller and shallower than non-urban lakes. Our results indicated that urban lakes were in more disturbed condition than non-urban lakes due to high total phosphorus and Chl-*a* concentrations, based on a reference condition for a given ecoregion. A significantly higher proportion of urban lakes were eutrophic nationwide, except in the Coastal Plains, Southern Plains and Temperate Plains ecoregions. In these ecoregions agriculture and pasture are the predominant land use and greatly influence lake water quality, probably by contributing nonpoint sources of phosphorus. Lakes in urban areas are at risk of eutrophication due to the rapid urban development. With the exception of few systems, most lakes are not managed which results in degradation of these valuable ecosystems.

Successfully Managing Urban Lakes for 30 Years in Eagan, Minnesota

Eric Macbeth, Jessie Koehle, Gregg Thompson, and Brian Leyendecker
City of Eagan, Minnesota

The City of Eagan, a suburb of Saint Paul, Minnesota, incorporates 33.5 square miles of rolling hills and shallow depressions. With about 1,150 surface waters, Eagan adopted Minnesota's first comprehensive municipal stormwater and water quality management plans in 1990. The award-winning plans classified waterbodies for recreational, natural, or stormwater priorities; instituted standards and policies; and established funding mechanisms for management programs and capital improvements. Multiple grants and loans supported watershed studies that identified improvement and protection projects.

We will summarize 30 successful years of protecting and improving urban lakes by reducing stormwater effects and enhancing recreational opportunities. Most Eagan lakes have met state water quality standards over three decades. Furthermore, despite over 40 percent more people and over 15 percent more impervious surface in Eagan since 1990, lake water quality has improved overall. Mann-Kendall trend tests on a group of 15 lakes showed statistically significant decreases in total phosphorus (TP, $p = 0.010$) and chlorophyll *a* ($p = 0.008$). Minnesota Pollution Control Agency (MPCA) now lists four lakes as impaired with excessive TP. But we expect similarly positive, future results from implementing lake-specific plans as we experienced with Fish Lake. In 2014, results enabled MPCA to "delist" it after we completed an alum application, operated our in-flow, alum-injection system, and implemented other Total Daily Maximum Load plans. Ongoing lake management programs include aquatic plant harvesting; analyses of lake sediments; alum applications; winter aeration; fisheries surveys and stocking; stormwater pre-treatment practices (*e.g.*, raingardens, iron-sand filters); and various stormwater pollution prevention programs.

Managing Urban Lakes; Unique Challenges and Needs

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

While often overlooked and underappreciated, urban lakes are important natural community resources, especially for inner-city youth. Often time these waterbodies are an "oasis" within the "concrete jungle" of urban centers. The ecosystem services provided by urban lakes are especially diverse, encompassing contact recreation, fishing, boating, flood control and even irrigation.

Urban lakes are subject to a host of unique problems and impacts, most of which are a function of their hydrology. Many rely largely on stormwater runoff as the main source of inflow. This results in a very temporally sporadic hydrologic budget and an inflow source characterized by elevated concentrations of various pollutants, including high concentrations of HABs stimulating nutrients. Additionally, development-related alteration of nearshore areas leads to shoreline erosion and a reduced littoral zone. The cumulative effect of these hydrologic and land-development impacts is impaired water quality, compromised habitats and the inability to meet community expectations.

Although the typical management response is reactive; focusing on the repeated application of algaecides and herbicides, with proper planning a more proactive, ecologically-based management approach can be implemented. While it may not be possible to make these waterbodies swimmable, it is possible to significantly improve their ecological services and functions and lessen the occurrence of nuisance algae blooms. This presentation provides examples of actual case studies involving the re-creation of littoral habitat, the construction of innovative urban stormwater management systems, and the installation of floating wetland islands as part of efforts to reclaim and improve urban lakes in New Jersey.

Waste to Utility: Harnessing Stormwater in Waconia

Tim Sundby[1] and Craig Eldred[2]
[1]Carver County Water Management Organization, Chaska, Minnesota; [2]City of Waconia Public Works Director, Waconia, Minnesota

The City of Waconia had a unique opportunity to utilize a new regional pond that was constructed as part of a highway project that occurred in 2015. Working with Carver County Water Management Organization, a reuse system was installed that combined the need for volume reduction requirements and a reduction to drinking water supplies. A large filtration basin was connected to the pond that meet water quality reduction requirements for business sites that connect to the system. The combination between volume reduction and water quality treatment results in new developments meeting all stormwater requirements for CCWMO Stormwater Permits. This allows each site to fully utilize their lot without having to install separate water quality and volume reduction BMPs to treat stormwater onsite. In 2019, the system delivered 4.1 million gallons of stormwater to 10 sites.

General Session 1I: Shallow Lakes

November 17, 2020 | 11:00 – 12:00

Experimental Stocking to Restore Amphipods (*Gammarus lacustris*) in Wetlands of the Upper Midwest, USA

Megan J. Fitzpatrick[1], Michael Anteau[2], and Danelle Larson[3]
[1]Minnesota Department of Natural Resources, Wetlands Wildlife Population and Research Group, Bemidji Minnesota; [2]US Geological Survey, Northern Prairie Wildlife Research Center, Jamestown, North Dakota; [3]US Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin

Amphipods, an important food resource for wildlife, have recently declined in wetlands of Midwestern North America. We are evaluating the efficacy of amphipod stocking for establishing self-sustaining populations of *Gammarus lacustris* in prairie pothole wetlands in Minnesota, USA, using a Before-After/Control-Impact study design. We stocked 22 wetlands with locally collected *G. lacustris* across winters 2017–2020. Each basin was paired with a nearby reference basin. All basins were surveyed for amphipods using standardized dip netting during the fall prior to stocking and each fall following stocking. Immediately prior to release, > 99% of amphipods were alive with intact limbs. In one basin, we used an underwater camera to monitor amphipods post-stocking. They mostly clustered on the underside of the ice around the stocking hole without apparent mass mortality for 7 days, but began to disappear (disperse or die) from the area thereafter. Despite initial survival, we found no *G. lacustris* in any post-stocking dip net samples (n = 15 wetlands). Our preliminary results suggest that stocking is not effective for establishing *G. lacustris*. However, *G. lacustris* could be persisting at low densities and may appear after several reproductive cycles; we will continue surveying stocked basins for another year. Our on-going companion study investigates physical and biological characteristics that support abundant naturally-occurring *G. lacustris*. This work should help identify characteristics that support or limit abundant *G. lacustris* in wetlands to inform future conservation decisions about stocking or restoration.

Managing Shallow Lakes in Minnesota for Wildlife and Water Quality: A 20-Year Perspective

Nicole Hansel-Welch
Minnesota Department of Natural Resources, Brainerd, Minnesota

The Minnesota Department of Natural Resources (DNR) Section of Wildlife Management has been managing shallow lakes in Minnesota to benefit wildlife for several decades with varying levels of intensity. Additional funding sources over the last two decades has allowed increased management efforts and routine pre- and post-management monitoring. Management is needed due to increasingly mild winters, wetter summers, and landscape alterations that have resulted in ecosystem changes leading to degraded habitat conditions. Active management, specifically drawdown, has proven to be an effective mitigation technique for some of these negative impacts. Drawdowns mimic the positive effects of droughts on shallow lakes. Improvements in lake condition generally last from 3–10 years before repeated management is necessary. There are many lakes where drawdowns are not feasible so landscape-level improvement is difficult to achieve. Strategies for successful projects include targeting lakes that have small watersheds, minimal connection to other water bodies and topography that allows drawdowns to eliminate most of the water from a basin. Limitations of drawdowns include inability to remove enough water and difficulty managing fish populations that may return to basin after re-flooding. Dramatic improvements are possible with in-lake management, but ongoing active management will be necessary to maintain habitat improvements. Public interest and support of active shallow lake management has increased as the DNR gathers empirical data demonstrating positive results.

Extreme Amphipod Abundance Was Linked With Distinct Aquatic Vegetation Assemblages

Danelle M. Larson[1], Breanna Keith[2], Demey Everett[3], Megan Fitzpatrick[4], Emily Schilling[3], and Michael J. Anteau[5]

[1]US Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin; [2]Bemidji State University, Bemidji, Minnesota; [3]Augsburg University, Minneapolis, Minnesota; [4]Minnesota Department of Natural Resources, Wetland Wildlife Population and Research Group, Bemidji, Minnesota; [5]US Geological Survey, Northern Prairie Wildlife Research Center, Jamestown, North Dakota

Amphipods are declining in the Prairie Pothole Region (PPR), with few wetlands hosting high abundances of *Gammarus lacustris* and *Hyalella azteca*. We aimed to quantify relationships between amphipod density and emergent and submergent plant communities in 50 PPR wetlands to better understand habitat conditions needed to produce high amphipod abundance. We included wetlands for field survey that would span the possible range of amphipod densities. We found 50% of the sites had amphipod densities > 500 amphipods/m^3 and several wetlands had extreme densities (7,000 amphipods/m^3). Multiple regression revealed *G. lacustris* were not associated with submergent or emergent vegetation prevalence, relative biomass, or species richness; in contrast, *H. azteca* densities were positively correlated to submergent plant prevalence. Amphipod species abundances were predicted by the vegetation community according to redundancy analysis. Amphipods were positively associated *Potamogeton spp.* and *Myriophyllum sibiricum*, and *G. lacustris* were positively associated with *Lemna trisulca*. Amphipods were negatively associated with the carnivorous plant, *Utricularia macrorhiza*. These aquatic plant species likely provide many services to amphipods, including: refuge from predation, reduced intraspecific competition by occupying the entire water column, a detrital food source, and increased dispersal rates to new wetlands by waterfowl. Our results confirm that protecting and enhancing vegetation communities can support invertebrates.

General Session 1J: Monitoring and Data Products

November 17, 2020 | 11:00 – 12:00

#Affordable Green Analytical Chemistry for Nutrient Testing

Ellen R. Campbell[1], Wilbur H. (Bill) Campbell[1], and Aimee H. Marceau[1,2]
[1]NECi Superior Enzymes, Lake Linden, Michigan; [2]Michigan Technological University, Houghton, Michigan

Excess nutrients plant phosphate that are not utilized by crops or soil microbes end up in the groundwater. Accumulation of excess nitrate and phosphate nutrients in the nation's waters is an increasing area of concern; examples today include nitrate removal costs for drinking water in Des Moines, Iowa, and toxic algal blooms in Lake Erie, affecting citizens in Toledo, Ohio. Improvements in nutrient management require better tools and technology. NECi has developed accurate test kits for non-lab users, designed to enable better practices in nutrient testing and management. Better management yields a cleaner environment. NECi's kits are based on enzymes as the detection agents. Enzymes are specific, sensitive biomolecules that can "find" their targets in complex matrices such as ponds, runoff, and coastal waters. The nitrate test kits are simplified versions of NECi's colorimetric EPA and standardmethods.org reagents and methods. The phosphate method is also enzyme-based, with results in the UV. When coupled with NECi's inexpensive handheld photometer, nonchemists can obtain reliable near-quantitative data onsite. All reagents are safe for users and the environment. And the methods require minimal sample preparation. Skill level is targeted at Citizen Science and STEM education. Development of NECi products has been funded by the Small Business Innovation Research programs of the USDA and National Science Foundation.

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

An Integrated Regional Approach to Sharing Water Quality Data: DataStream's Open Data Platform

Carolyn DuBois and Lindsay Day
The Gordon Foundation, Toronto, Ontario, Canada

A rich diversity of lake monitoring programs and studies are collecting water quality data in watersheds across North America. While each provides value in their own right, there are enormous benefits to be realized when data across these initiatives can be brought together in consistent, standardized formats and accessed through user-friendly, open-access databases and tools. DataStream is an online open data platform that was developed by the Gordon Foundation and its partners to facilitate the exchange of water quality data across jurisdictions and diverse programs operating within Canada's major drainage basins. DataStream was first launched in the Mackenzie River Basin, through a unique collaboration between the Gordon Foundation and the Government of the Northwest Territories, Mackenzie DataStream's founding partner. Following its success in this northern basin, regional DataStream hubs have since been established in Atlantic Canada (2018) and the Lake Winnipeg Basin (2019), with more regional hubs set to come online in the coming years. DataStream leverages the same integrated data-sharing infrastructure and technology across hubs, while its regional implementation helps foster collaboration and network building across communities and initiatives that share a common drainage basin. By aligning with the WQX schema for the exchange of water quality data that is widely adopted in the US, DataStream is also facilitating greater interoperability of data across transboundary watersheds and lakes. This presentation will provide an overview of this data sharing platform with a focus on the rich diversity of research and monitoring initiatives that use it to share data.

Using Mobile Technology to Access Environmental Map Data, Streamline Data Collection, and Improve Workflow on Environmental Projects

Elizabeth Reetz, Mary De La Garza, and John Doershuk
ECR Logic, LLC, Iowa City, Iowa

Whether involving grant or compliance-related research, the need for efficient environmental field data collection has never been greater as funding and political pressure on agencies and regulations continues to increase. New technologies are being created that show excellent potential integrating precision GPS, cloud-based data accessibility, and sophisticated Geographic Information System data management linking home office and remote field locations. One available innovation is ECR FieldPro™ which provides extensive map library accessibility, GIS functionality that does not require specialized training to operate, supports syncing of desktop and mobile devices, and provides in-field data collection tools that function regardless of Wi-Fi connection. Case studies from the Midwest demonstrating the utility of ECR FieldPro™ in 1) initial project scoping and field planning, 2) field data collection and real-time communication of results, and 3) efficient and increased accuracy reporting will be demonstrated. The implication of these case study results is that the opportunity for improved workflows centered on digital field data collection are readily achievable.

Financial disclosure: The authors of this abstract have a financial interest in ECR Logic, LLC, and ECR FieldPro™.

Modern Nitrate Monitoring Methods

Brent Register and Daniel Penczak
OTT Hydromet, Sterling, Virginia

As scientists, engineers, and water managers it is challenging to navigate an ever-increasing amount of sensor options that all can achieve a certain goal. There are many benefits to matching the right sensor to the right application within the available budget. We will also discuss the measurement of nitrate and its applicability to helping to determine total nitrogen loading for a given body or water or watershed and the theory behind why nitrate measurement makes sense in such a situation. In this presentation we will also compare and contrast different deployable Nitrate monitoring solutions helping to provide some insight into which instrument might be best for a given situation. This will include spectral ranges utilized, interference compensation, and types of UV lamps utilized.

With this presentation, attendees will:

- Receive an overview of several available optical instruments and methods.

- Learn the importance of optical nitrate sensors and their components.

- Learn about measurable concentration ranges, and accuracies of the different available sensors.

- Understand what maintenance is involved and how often these practices need to be employed.

- Understand the importance of nutrient monitoring programs in organizations like the USGS and USDA.

- Explore how data can help convince your community about the importance of nutrient reduction.

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

Enumeration and Classification of Freshwater Algal Samples Using Semi-automated Imaging Flow Cytometry and Supervised Machine Learning Techniques

Cory Sauve, Denise Clark, Hannah Schroeder, and Ann St. Amand
PhycoTech, Inc., Saint Joseph, Michigan

The manual enumeration and identification of algal samples is a time-intensive process requiring considerable expertise in algal taxonomy. Semi-automated enumeration using imaging flow cytometry, coupled with an accurate classification model, can process samples and deliver data on a timescale representing a fraction of the processing time of traditional, manual counts. In this talk, we will discuss sample processing using an Imaging Flow Cytobot (IFCB) and subsequent classification utilizing two supervised machine learning methods. We evaluated the ability of random forest and convolutional neural networks to classify over 250 freshwater phytoplankton samples. These samples represent 137 classes separated by taxonomy and functional group and include 200,000+ images based on live material. Various methods were evaluated to determine algal targets, augment images, and extract relevant features. These methods were implemented in both the MatLab and Python programming environments. We will discuss the accuracy of both supervised learning approaches, considerations that should be made, and how semi-automated algal classification can be utilized to better understand and evaluate algal assemblages.

General Session 1K: Pollution

November 17, 2020 | 11:00 – 12:00

Whole-Lake Nitrate Addition to Control Methylmercury in Onondaga Lake, New York: A Review of the First Nine Years (2011–2019)

David Andrews[1], David Matthews[1], David O'Donnell[1], Anne Burnham[2], and Heather Philip[2]
[1]Upstate Freshwater Institute, Syracuse, New York; [2]Parsons, Syracuse, New York

Onondaga Lake, located in Central New York adjacent to the city of Syracuse, has a long history of cultural and industrial pollution, which led to eutrophication and direct toxicity impacts resulting in loss of use of the lake by the mid-20th century. As part of the record of decision issued by New York State in 2005 outlining requirements for remediation and recovery objectives for the lake, Upstate Freshwater Institute was part of a team that developed a novel management method to abate the production of methylmercury from anoxic hypolimnia of stratified lakes. Industrial dumping of inorganic mercury (Hg_2^+) directly into Onondaga Lake left elevated levels in sediments, which is methylated under anaerobic conditions during summer thermal stratification. In lieu of oxygenation, the addition of an alternate electron acceptor, nitrate (NO_3^-), was tested and approved for use. A three year, whole lake pilot study beginning in 2011 resulted in decreases in methylmercury production by 94% compared to recent previous years, and full scale nitrate addition in Onondaga Lake continues today. The scale of the Onondaga Lake Nitrate Addition Project is larger than any other of its kind and offers a unique opportunity to study this management technique *in situ*. Results from the first nine years of nitrate addition are presented, including overall trends and analysis of monitoring data with a focus on the engineering and logistics required to carry out this type of large scale project.

Pollution Assessment of the Waterbodies of the NE Yucatán Peninsula. Case Study: Cenotes Near Playa Del Carmen, Mexico

Luis Bravo-Inclan, Jose Javier Sanchez-Chavez, Ana Cecilia Tomasini-Ortiz, and Luis Gonzalez-De-Hita
Mexican Institute of Water Technology (IMTA), Jiutepec, Morelos, Mexico

Hydrogeochemical and water quality from three cenotes, located along the Cancun-Tulum touristic corridor, Mexico, were assessed to determine whether the cenotes may be considered safe for bathing contact & touristic activities. The "Riviera Maya" located on the Mexican Caribbean is experiencing an accelerated development of its touristic infrastructure and human growth. The aim of this study done in 2013, was to establish the degree of water quality impact caused by the horizontal movement of treated and raw wastewater (WW) from the WW Treatment Plant (WWTP), over three rural cenotes. The sampling work was done in accordance with the Mexican normativity; the following parameters were included: temperature, TSS, OD, pH, Secchi disk, BOD, COD, conductivity, TP, TN, ammonia nitrogen, detergents, oil & grease (O&G), fecal and total coliforms, and toxicity with Daphnia magna. In relation to the WWTP of Saástun-Já, several parameters exceeded the Mexican WW Criteria (NOM-001-SEMARNAT-1996), such as: TSS, O&G, TN and fecal coliforms. During the rainy season, it was found that the WW migrated toward the zone where the rural cenotes are located (named as Chano 1 and Chano 2, and the more distant Chak-Tun cenote). Of these waterbodies, only the Chano 1 cenote presented late-year evidence of WW pollution. The behavior of the rural cenotes was unpredictable due to the complex dynamics within the karstic system in the study area. Finally, the local authorities were alerted of these findings, to avoid or to control future pollution problems, caused by WW and treated water from the near WWTP.

General Session 1M: Human Dimensions

November 17, 2020 | 11:00 – 12:00

Training the Next Generation of Limnologists: A Call to Include Service Learning and Engaged Scholarship in Field Courses

Victoria Chraibi
Tarleton State University, Stephenville, Texas

Of the top ten desirable skills in the modern workforce, half of them are "soft skills" associated with social competence. Moreover, four of the five reasons that most new hires fail in a position are related to social skills rather than technical competence. Professional social skills are not an inherent focus of scientific courses, so there is a need and an opportunity to develop additional training embedded in current content to better train the next generation of limnologists to be professionally competitive and successful. Engaged scholarship through service learning, in which students provide community service to a local, community-based partner through lab and field activities, helps students connect classroom concepts to the social importance and application of what they are learning. This talk presents an example of engaged scholarship in a limnology class with a community partner regarding pond management and discusses tips for success and pitfalls to avoid. Overall, engaged scholarship requires planning, communication, and evaluation to be effective. Students must understand the purpose and expectations of the service learning approach and reflect upon the process as part of the transformative learning process. Ultimately, the key to the success of a service learning program is to ensure reciprocal benefit with the community partner, asking them what they need and innovating how the course can fulfill a need rather than offering them a specific predetermined service. This shift in mindset opens possibilities for collaboration with scientific organizations, citizen scientist groups, and new non-scientific partners to the reciprocal benefit of all.

Navigating Troubled Waters – Tools for Water Resources Professionals

Diane Lynch
Prior Lake-Spring Lake Watershed District, Prior Lake, Minnesota

Who would have imagined we would have to abruptly change our lives almost overnight? With the exception of epidemiologists, I'll bet few people did. A few months into this pandemic, our lives are not the same as before and may never be. There are important lessons we've learned about Nature's resilience, our government, our communities, our families and ourselves. How will these lessons affect the work that we will continue to do as water resource professionals? Even during normal times, successful water resources projects relied upon good science, teamwork, funding and dedication. Our teams will continue to be comprised of individuals from many different sectors but now they have the additional burden of grappling with COVID-19 while striving to protect water resources. This workshop, probably unlike any other NALMS has offered, will focus on the most important person in the room—the individual—and demonstrate skills that will help ensure that person will continue to be successful in his/her work even when balancing the challenges of living in uncertainty, by learning a few mindfulness techniques. Mindfulness is a process we can use to master and restore ourselves.

I will teach participants simple mindfulness techniques they can do throughout each workday to strengthen their emotional resilience, respond to stressors and get refocused. Those techniques include grounding, tapping, visualization, and setting intentions. I will provide reference material on the techniques, along with a bibliography of articles and books written by leaders in this field for those interested in exploring mindfulness further.

Wisconsin's Shoreland Owners: Factors Influencing Future Lake Protection

Eric Olson[1] and Robin Rothfeder[2]
[1]Extension Lakes, Stevens Point, Wisconsin; [2]Extension Center for Land Use Education, Stevens Point, Wisconsin

Extension Lakes conducted a survey of Wisconsin shoreland property owners in early 2020. Our goal was to capture a baseline of owners' perceptions of lake issues, motivations for taking lake protection actions, and barriers to implementing actions. Our survey approach allowed us to match respondents to their corresponding lake and integrate spatial and water characteristics into our analysis. We found that respondents' characterization of water quality issues largely corresponds to actual conditions found on their lakes. We were surprised to learn that landowners view cost as a barrier to implementing practices like shoreland native plants and rain gardens. We also found that compared to non-members, members of lake associations perceive that low support among their neighbors is a barrier to taking actions on lake health. We will discuss how these results will be integrated into marketing and outreach strategies for Wisconsin's Healthy Lakes program, an effort to increase lake-friendly actions in riparian communities. We will also show how statewide surveys can provide useful reference points for lake-specific surveys that are commonly used in lake planning efforts.

Researching the Influence of Anthropogenic-Created Disturbances in the Nearshore of Lakes: Navigating a High Visibility Public Arena as Scientists

Frank Wilhelm[1], Heather Crawford[1], and Basile Cousin[2]
[1]Department of Fish and Wildlife Sciences, College of Natural Resources, University of Idaho, Moscow, Idaho; [2]Lumière University, Lyon 2, France

Humans are inextricably linked to water due to our physiological needs, needs for the production of goods (*e.g.*, industry and agriculture) and our general well-being (*e.g.*, recreation). Given the wide variety of recreational pursuits related to water – from sitting on a tranquil shoreline, to low impact paddle sports to high horsepower motorsports that involve the generation of large wakes ideal for surfing – pits user groups against each other and puts policymakers between a rock and a hard place. Underlying the success and continuance of these multi-uses is a high-quality resource (high water quality) without which the uses and associated ancillary benefits (from property taxes to number of guest room nights, etc.) would cease. This offers a common ground from which to approach these conflicts. Here we provide insights from our experiences as scientists working in this milieu as a neutral, objective middle party to undertake meaningful research to provide a solid foundation for future decisions and to communicate findings and limnological basics to a wide variety of audiences ranging from the interested homeowner, to county commissioners, legislative committees and peer scientists.

General Session 2A: HAB Response

November 18, 2020 | 11:00 – 12:00

Cyanobacteria Harmful Algae Blooms Outreach and Monitoring Efforts

Joan Hardy[1], Ellen Preece[2], and Lorraine Backer[3]
[1]Washington Department of Health, Olympia, Washington; [2]Robertson-Bryan Inc. Sacramento, California; [3]Centers for Disease Control and Prevention, Chamblee, Georgia

A widespread effort is underway to improve awareness of cyanobacteria harmful algae blooms (cyanoHABs) across the USA using a variety of monitoring programs and public health outreach measures to protect people, pets, and livestock. To determine the status of cyanoHAB outreach and monitoring efforts, two questionnaires were distributed to all 50 states. One questionnaire focused on cyanoHAB exposure to humans from drinking water and the second targeted exposure through recreational activities. All 50 states plus the District of Columbia (DC) responded to the recreational survey; 46 states plus DC responded to the drinking water survey. All states except Alaska answered that microcystins were the cyanotoxins of greatest concern for recreational exposure; microcystins were also of greatest concern for drinking water with the exception of Utah (anatoxin-a in reservoirs was greatest concern) and Rhode Island (microcystins and anatoxin-a in reservoirs and ponds were greatest concern). Regional comparisons disclosed a lack of programs in southern states relative to northern states; reasons for this geographical difference are unknown. Very limited funding is available for outreach and monitoring programs, with efforts ranging from extensive in some states to non-existent in others. Interestingly, recreational outreach efforts are more extensive than drinking water outreach (only 16 states reported having some type of drinking water outreach program compared with 35 states with recreational outreach). Preferred cyanoHAB outreach methods were websites and press releases. Our results establish baseline information to help determine what future direction cyanoHAB outreach and monitoring programs.

An Example of Algae Trend Analysis and Data Visualization

Katherine Mayo and Shahram Missaghi
City of Minneapolis, Minnesota

Algae blooms can turn the water green and smelly and contribute to fish kills by creating dead zones in the water when they sink and decompose. Algae blooms can produce toxins posing serious health risks to people and animals. More frequent HABs may be happening triggered by increased urban and agricultural runoff, as well as a changing climate. Algae population is very dynamic and it changes within lakes, across a region, and over time, making algae population trend analysis difficult. It becomes even more so – communicating the results of these trends analysis to area residents, policymakers, and resource managers. There is a need for effective tools in aiding lake managers in communicating around algae trends and populations. In this presentation, we will show how we used geographical information system generated maps to create time-lapse videos to demonstrate the development of algae population dynamics on multiple lakes over the years. Algae data visualization videos or films can also aid in the tracking, monitoring, and forecasting of algae – particularly harmful algal blooms. Examples will be shared.

A Tale of Two Contrasting HAB Control Plans

Rob Zisette
Herrera Environmental Consultants, Seattle, Washington

Algae management plans were prepared concurrently for two small, shallow lakes in western Washington that are both closed each year due to exceedingly high concentrations of anatoxin-a produced by *Dolichospermum*. Lone Lake is polymictic with drainage from rural residential and small farms served by septic systems. Anderson Lake stratifies and its watershed is entirely within a forested state park. Phosphorus budgets for both lakes show high internal phosphorus loading is primarily causing the algae blooms. Using grants provided by the state, in-lake management techniques were evaluated and recommended to reduce the HABs. Lone Lake stakeholders chose no action due to funding limitations and potential recovery by recent grass carp removal efforts and the return of native aquatic plants. Anderson Lake stakeholders chose no action because paleolimnological analysis of sediment pigments indicate cyanobacteria are naturally present and management of natural conditions does not align with park management policy.

General Session 2B: Fish Management

November 18, 2020 | 11:00 – 12:00

Review of Habitat Requirements, Distributions, and Protections of Cold Water Fish Species in Minnesota Lakes

Derek Bahr[1] and R. William Bouchard, Jr.[2]
[1]Minnesota Department of Natural Resources, Brainerd, Minnesota; [2]Minnesota Pollution Control Agency, St. Paul, Minnesota

Numerous lakes throughout Minnesota support populations of lake trout, lake whitefish, and cisco. These species require cold, well-oxygenated water to survive; however, various anthropogenic stressors such as eutrophication and climate change threaten to reduce oxythermal habitat in these lakes, particularly during the summer months. Recognizing this, the Minnesota Department of Natural Resources and Minnesota Pollution Control Agency began a collaborative effort to review specific habitat requirements of these three cold water species, inventory lakes where they have historically occurred or presently occur, and evaluate existing water quality standards to determine where additional protections may be warranted. Reviews of these components indicate that although hundreds of Minnesota lakes support at least one cold water species, existing water quality standards applied to these lakes may not sufficiently protect the oxythermal habitat necessary for each species' persistence. This information, in addition to the development of cold water species-specific dissolved oxygen, temperature, and nutrient thresholds, will be critical to establishing a new framework to protect or restore lakes and their associated cold water communities.

The Phalen Chain of Lakes: A Decade of Water Quality Improvement With Carp Control, Alum Treatment, and Stormwater Management

William Bartodziej[1], Przemek Bajer[2], Justine Dauphinais[3], Eric Korte[1], Keith Pilgrim[4], Simba Blood[1], and Peter Sorensen[5]
[1]Ramsey-Washington Metro Watershed District, Little Canada, Minnesota; [2]Carp Solutions, New Brighton, Minnesota; [3]Coon Creek Watershed District, Ham Lake, Minnesota; [4]Barr Engineering, Minneapolis, Minnesota; [5]University of Minnesota, St. Paul, Minnesota

In an intensive ten-year effort, in-lake and stormwater management practices were implemented to improve water quality in the Phalen Chain of Lakes, which is composed of a mix of deep and shallow urban lakes that border Saint Paul, Minnesota. Through netting and nursery area management, common carp (*Cyprinus carpio*) biomass declined from 175 to 40 kg/ha in Kohlman, Gervais, and Keller Lakes. An alum treatment was conducted in Kohlman Lake to reduce internal phosphorus loading. In addition, stormwater best management practices (BMPs) were also conducted in conjunction with in-lake management practices. There were marked differences in how deep versus shallow lakes responded to management in the Phalen Chain. Generally, carp biomass reductions and the alum treatment showed a statistically positive influence on total phosphorus (TP), chlorophyll *a* (Chl-*a*), and Secchi depth (SD) in the shallow lakes, while standard water quality monitoring did not detect improvements in the deeper lakes, specifically Lakes Gervais and Phalen. In addition to safeguarding the Phalen Chain from new carp infestations, the elimination of carp in Casey Lake and Markham Pond (two connected stormwater ponds that were carp nursery areas) significantly improved water quality. As TP declined, Chl-*a* and SD responded in a way that put these systems in a clear water state. For the shallow lakes, there was a notable shift in the relationship between TP and Chl-*a* for the pre and post-management periods suggesting that other factors, such as the increased abundance of aquatic plants, resulted in water quality improvements beyond solely TP reductions.

Development of Dissolved Oxygen, Temperature, and Nutrient Thresholds to Protect Cold Water Fish Species in Minnesota Lakes

R. William Bouchard, Jr.[1] and Derek Bahr[2]
[1]Minnesota Pollution Control Agency, St. Paul, Minnesota; [2]Minnesota Department of Natural Resources, Brainerd, Minnesota

Minnesota's current water quality standards framework provides protections for lakes which support or are managed for trout, but these standards do not specifically protect other cold water fish species such as cisco and lake whitefish. Many populations of cold water fish species in Minnesota are threatened by a warming climate and eutrophication because these species require cool, oxygenated water. The Minnesota Department of Natural Resources and Minnesota Pollution Control Agency are collaborating to inventory lakes which support lake trout, cisco, and lake whitefish and to develop water quality standards which specifically protect these species. This effort includes the development of protective thresholds which address dissolved oxygen and temperature requirements (*i.e.*, oxythermal habitat) for these fish species. In addition, thresholds for total phosphorus and chlorophyll *a* have been determined which link to conditions needed to maintain protective levels of dissolved oxygen. These analyses and previous research has determined that each species has different requirements which necessitates species-specific standards. Designating Minnesota's lakes that support cold water fish and documenting which cold water fish species occur in these lakes will allow the application of species-specific standards. The resulting framework provides standards which can be used to maintain populations of these threatened fish species and to protect or restore these important aquatic resources.

*Analysis of Game Fish Community Composition Pre and Post Renovate™ Herbicide Treatment on Saratoga Lake, New York

Samantha Carey and Daniel S. Stich
State University of New York College at Oneonta, Oneonta, New York

A three-year study was conducted to examine fisheries community abundance of Saratoga Lake, New York after an application of Renovate™ herbicide treatment to control Eurasian watermilfoil (*Myriophyllum spicatum*). Boat electrofishing surveys were conducted at night, 1 year pre-treatment, 6 months post-treatment and 1 year post-treatment. Five sites along the northeast shore were sampled, species occurrence and total length (TL) were recorded. Data were analyzed using non-metric multidimensional scaling (NMDS) and analysis of similarities (AMOSIM) models to compare community composition over the 3-year study. Bluegill (*Lepomis macrochirus*) abundance decreased post-treatment. The ANOSIM model showed significant difference in the fisheries community composition pre and post-treatment. The NMDS stress level suggests that two dimensional solutions will accurately represent community composition within sites across a 3-year study. Decreased amounts of rooted aquatic macrophytes such as Eurasian watermilfoil, could explain the changes in community composition between years.

Using the Fish Hotel Kit to Reach Out to Audiences of All Ages

Lynn Markham[1] and Justin Sipiorski[2]
[1]University of Wisconsin-Stevens Point and Extension, Stevens Point, Wisconsin; [2]University of Wisconsin-Stevens Point, Stevens Point, Wisconsin

The Fish Hotel Kit was designed by Wisconsin Extension and University of Wisconsin–Stevens Point faculty to inspire people of all ages to take action to help fish. We've found that people are often drawn into lake protection more effectively with fish stories than by phosphorus levels or Secchi depths. This kit uses stories to hook people on two lake protection measures: leaving fallen trees in the water to serve as fish hotels, and reducing impervious surfaces near water bodies. Through these two practices, the kit explains their impacts on specific fish species as well as on the lakes and rivers themselves. In the fall of 2018, 150 Fish Hotel Kits were distributed upon request to Wisconsin schoolteachers, Extension educators, and nature center educators. A year later, 53 of these educators responded to an online survey. 83% of respondents rated the kit an 8 or higher on a 10-point scale, and identified their favorite components. Educators have used the kits with lake groups, elementary school students, 4-H groups, reluctant readers, local elected officials making lake-related zoning decisions, and senior citizens. Educators reached 1,200 people with Fish Hotel Kits in the first year. We'll also introduce you to our next foray into lake protection through fish.

General Session 2C: Drawdowns

November 18, 2020 | 11:00 – 12:00

The Lake Christina Story: Six Decades of Shallow Lake Management

Nicholas Brown[1], Nicole Hansel-Welch[2], and Todd Call[3]
[1]Minnesota Department of Natural Resources, Fergus Falls, Minnesota; [2]Minnesota Department of Natural Resources, Brainerd, Minnesota; [3]Minnesota Department of Natural Resources, Glenwood, Minnesota

Lake Christina is a 3,950-acre shallow lake in west-central Minnesota that has been historically important to migrating waterfowl, especially canvasbacks (*Aythya valisineria*). Managers first noticed declines in waterfowl use in the early 1950s and later determined that habitat losses, resulting from increased over-winter fish survival, were the cause for lower waterfowl use. Beginning in the mid-1960s, managers began intensively monitoring the lake and applied a first fish-toxicant treatment, resulting in improved habitat conditions and increased waterfowl use. Additional fish toxicant treatments in 1987 and 2003 resulted in gains in habitat quality and waterfowl use, but treatments proved difficult and costly, leading local partners to pursue other means of managing the lake. In 2010, an electric-pump system was installed at the lake outlet, allowing drawdowns to manage habitat rather than chemical treatments. Wildlife managers adopted a lake management plan with submerged plant coverage and water quality goals to provide guidance on when to implement drawdowns. Since that time, the Minnesota DNR has conducted three (3) drawdowns on the lake leading to decreased total phosphorous and increased submerged plant growth in each instance, though lasting for shorter time intervals than previous fish toxicant treatments. Increasing local precipitation has made conducting drawdowns difficult, requiring an adaptive management approach. The Minnesota DNR and partners associated with the management of Lake Christina continue to work toward improved habitat conditions on this important waterfowl migration staging lake.

Ecological Patterns of Shallow Littoral Zones in Reservoirs Undergoing Annual Wintertime Water Level Drawdowns

Jason Carmignani[1] and Allison Roy[2]
[1]Massachusetts Division of Fisheries and Wildlife, Natural Heritage and Endangered Species Program, Westborough, Massachusetts; [2]US Geological Survey, Massachusetts Cooperative Fish and Wildlife Research Unit, University of Massachusetts, Amherst, Massachusetts

Annual winter drawdowns are a widely used management practice in impounded northeastern USA reservoirs used for recreation that partially expose littoral zones to freezing and drying to reduce aquatic vegetation, among other purposes. Although winter drawdowns are a common management practice, limited study exists on its impacts to littoral zones, particularly for relatively small drawdown magnitudes (*i.e.*, < 2–3 m). We estimated the relative influence of winter drawdown on physical habitat conditions (*e.g.*, macrophytes, coarse wood, sediment texture; n = 21 lakes), freshwater mussel density and size (n = 9 lakes), and macroinvertebrate abundance and composition (n = 14 lakes). We found increased drawdown magnitude was correlated with coarser substrates and reduced silt, reductions in macrophyte biomass and biovolume, and proportional increases of macrophyte taxa with annual longevity strategy and amphibious growth form. During normal water levels, we found markedly lower freshwater mussel densities at drawdown-exposed depths compared to the same depths in non-drawdown lakes. We also found drawdown magnitude influenced macroinvertebrate taxonomic and functional composition with evidence that suggests several drawdown-sensitive taxa (*e.g.*, Amnicola) and traits (*e.g.*, semivoltinism). Results from this work will contribute valuable information to facilitate water level management decisions at local, state, and regional levels.

Use of Drawdown as a Shallow Lake Fisheries Management Tool

Scott Mackenthun
Minnesota Department of Natural Resources, Hutchinson, Minnesota

Shallow lake drawdowns in Minnesota are an important tool for wildlife managers. However, the reduction of benthivore biomass, consolidation of substrates, and the return of rooted macrophytes and a clear water stable state can benefit both wildlife and fish. Legislative changes approved in 2012 allowed for temporary drawdowns of public waters, without formal wildlife designation, provided the lake management plan outlines how a drawdown will be conducted and a formal public hearing for public consent is held. This process gives both wildlife and fisheries managers the ability to use drawdowns as a management tool more readily and can be utilized by local government units as well. As annual winterkill frequency in shallow lakes declines, periodic temporary drawdowns through the M.S. 103G.408 public hearing process is a fisheries management tool that can be used to jump start or restore boom and bust fisheries and rearing opportunities.

Assessing Aquatic Habitat in a Lentic System With Winter Drawdown

Kellie Merrell, Leslie Matthews, Eric Davis, and Jeff Crocker
Vermont Department of Environmental Conservation, Montpelier, Vermont

The Vermont Water Quality Standards require the full support of aquatic biota, wildlife, and habitat. Green River Reservoir is a mesotrophic reservoir used for hydroelectric power generation and quiet recreation in Vermont. The reservoir boasts a largely intact, undeveloped shoreline. Prior to recent dam relicensing, a drawdown of 2–3 m was typically performed each winter. To assess the impact of these winter drawdowns on lake littoral habitat, we surveyed the reservoir in 2014. The littoral habitat assessment revealed that the composition of littoral biota at reservoir sites was significantly different from the composition of littoral biota at undeveloped reference sites on mesotrophic waterbodies that do not experience drawdowns. The littoral area was dominated by macrophytes in the reference sites, whereas the aufwuchs community dominated in the reservoir sites. Reduced macrophyte abundance represents a direct effect of drawdown on aquatic biota. In addition, reduced macrophyte abundance indirectly effects aquatic biota since many other biota rely on macrophyte beds to support life-cycle functions. Fewer odonate exuviae were also found at the reservoir sites than at the reference sites. When littoral areas become dewatered, the aquatic biota that have evolved to live in these areas experience a major disturbance that can include exposure to desiccation and freezing conditions. The new water quality certification limits winter drawdowns to 0.45 m. Minimizing the frequency and duration of these disturbances is expected to provide ecological benefits to the aquatic biota and habitat at Green River Reservoir in support of the Vermont Water Quality Standards.

Hydrology of Annual Winter Water Level Drawdowns in Recreational Lakes of Massachusetts, USA

Allison Roy[1], Jason Carmignani[2], Jason Stolarski[3], and Todd Richards[3]
[1]US Geological Survey, Massachusetts Cooperative Fish and Wildlife Research Unit, University of Massachusetts, Amherst, Massachusetts;
[2]Massachusetts Division of Fisheries and Wildlife, Natural Heritage and Endangered Species Program, Westborough, Massachusetts;
[3]Massachusetts Division of Fisheries and Wildlife, Westborough, Massachusetts

Annual winter water level drawdown is commonly employed by local authorities in lakes of the Northeast USA for the stated purposed of controlling macrophytes. Massachusetts provides general guidelines for lake managers to implement and practice winter drawdowns; however, empirical water level records are scarce to assess guideline adherence and link to littoral habitat conditions. We continuously monitored (*e.g.*, bihourly) water levels in 18 drawdown and 3 non-drawdown lakes over 3–4 years. Our results show an inter-lake magnitude gradient (median = 0.56 m, range = 0.07–2.66 m) with intra-lake consistency across years. Corresponding magnitudes generated exposure of 1.3–37.6% (mean = 12.7%) for entire lakebeds and 9.2–71.1% (mean = 25.8%) for littoral zones. Winter drawdown durations averaged 161 days and ranged widely from 5–246 days with higher recession and refill phase durations in lakes with deeper drawdown magnitudes. Drawdowns were consistently initiated prior to the November 1 guideline (83.1%) and refilled to summer reference levels after the recommended date of April 1 for 70.6% of drawdown periods. These results may help lake managers refine hydrological guidelines for winter drawdowns in anticipation of climate change projections, along with a growing body of research demonstrating the ecological impacts of winter drawdowns.

A Grassroots Effort to Bring Back Fulda Lakes

Jan Voit
Heron Lake Watershed District, Heron Lake, Minnesota

This grassroots endeavor started on behalf of Fulda townspeople noticing the degradation of First and Second Fulda Lakes, located within city limits. Through strong partnerships, the grassroots ideas turned to reality. The HLWD was able to apply for funds based on the needs described by local landowners. Their participation was a key factor in project initiation.

Water quality improved greatly as a result of the drawdown, fish kill and reclamation projects, and education. Fulda Lakes have a maximum depth of seven feet. Since 2008, water clarity readings from both lakes have been documented to the bottom of the lake throughout the year.

Partnerships are essential in utilizing the best resources available and maximizing the cost effectiveness of any project or education event. Fulda Lakes are seeing improvement as a result of collaboration that made the drawdown, reclamation, and restoration projects possible.

General Session 2D: Chemical (Nutrient) Management

November 18, 2020 | 11:00 – 12:00

Geochemical Augmentation With Alumina and Iron for Phosphorus Removal and Hab Control in Reservoirs: Conclusions From Case Studies

David Austin and Roger Scharf
Jacobs, Mendota Heights, Minnesota

The ultimate fate of phosphorus (P) in a reservoir is either to flow out in particulate/soluble form or to bind with mineral complexes permanently in sediments. Phosphate binds with aluminum (Al) and with ferric iron (Fe^{3+}). Geochemistry of reservoirs varies widely. Deficiency of dissolved or sediment Al or Fe prevents retention of phosphate. Al is redox insensitive, but Fe-binding of P requires sustained dissolved oxygen flux to the sediment surface. Continuous dosing at soluble, non-flocculating, concentrations can create a phosphate-scavenging geochemistry, reducing TP and primary productivity. There are both long-standing and recent reference projects. Design principles are empirical and need development. Because infrastructure demands are modest there is potential for widespread deployment of geochemical augmentation methods.

For continuous dosing, it is essential to maintain total Al or Fe concentration below chronic toxicity thresholds. With Fe the drinking water standard of 0.3 mg/L is ecologically safe. Care must be taken to not enrich the photic zone with Fe, which can act as a micro-nutrient in Fe-limited waters. With Al the 2018 US EPA aluminum ambient criteria calculate chronic toxicity based on pH, hardness, and dissolved organic carbon. Depending on site geochemistry, this limit is likely to be 0.3 to 1.0 mg/L total Al. This presentation will review geochemical augmentation with ferric iron in five reservoirs, alumina in three reservoirs and a stormwater pond. Large reductions in total phosphorus and primary productivity were observed. Harmful algae blooms were suppressed.

Reducing SRP in Outflow from Impacted Wetlands

Brian Kallio, Diane Spector, and Ed Matthiesen
Wenck Associates, Golden Valley, Minnesota

Urban Wetlands receiving many decades of nutrient and sediment-rich runoff are at risk of transforming from nutrient sinks to nutrient sources. The hydrology has been altered by increased runoff volumes and ditching for drainage and flood prevention. These wetlands are more susceptible to sediment nutrient release under anoxic conditions and discharge is often high in soluble reactive phosphorus (SRP) and low in dissolved oxygen. Wetland 639 in Crystal, Minnesota was identified as a significant source of SRP to Twin Lakes. Twin Lakes has an EPA-approved impairment for Mercury in fish tissue; Nutrients; PCB in fish tissue; and Perfluorooctane Sulfonate (PFOS) in fish tissue. Iron-enhanced sand (IES) filters have shown promise in reducing SRP, but guidance recommends that the medium dry out between storm events and remain aerobic. The Shingle Creek SRP Reduction Project is testing three kinds of sand filters – IES and two different proprietary media, a phosphorus sponge, the other an iron enhanced activated alumina – to determine which is the most cost-effective under saturated, anoxic conditions. In 2019 a wetland outlet weir was modified with the three filters in parallel to subject each to the same conditions. Flow through the filters was recorded, and inflow and filter discharge was tested for water quality parameters.

Results from 2019 contradict the expectation that IES would not perform well under continuously saturated conditions. The activated alumina had the highest removal efficiency and flow rate. Both the IES and the activated alumina performed better than the sponge. The IES was most effective in terms of pounds of phosphorus removed per dollar. 2019 was an atypically wet year, and monitoring will be repeated in 2020. This presentation will overview the filter design and the assumptions and methods to calculate SRP removals and will present the 2019 and 2020 results.

*Herbicide Treatment of an Aquatic Invasive Plant (*Nymphoides peltata*) in a Drinking Water Reservoir

Benjamin T. Lamb[1], Abigail A. McCrea[1], Scott H. Stoodley[1], and Andrew R. Dzialowski[2]
[1]Oklahoma State University, Environmental Science Graduate Program, Stillwater, Oklahoma; [2]Oklahoma State University, Department of Integrative Biology, Stillwater, Oklahoma

A spot-specific herbicide treatment was used to control an invasive aquatic plant, yellow floating heart (*Nymphoides pertalta*), in a 3,350-acre drinking water reservoir in Stillwater, Oklahoma. The purpose of this research was to document the success of the treatment using remotely sensed Sentinel-2 satellite imagery. Water quality data was also collected to determine if the dying vegetation impacted biological oxygen demand and dissolved oxygen concentrations in a cove of the reservoir. The aquatic herbicide ProcellaCOR (active ingredient = florpyrauxifen-benzyl) was applied to the reservoir by a certified applicator in July 2019. Total surface coverage of yellow floating heart prior to the herbicide application was approximately 53 acres. Surface coverage was then reduced by more than 90% within 14 days of the treatment and it was less than 3 acres within 50 days of the treatment. The effect of the herbicide treatment also carried over into the 2020 growing season. The herbicide treatment resulted in only short-term increases in biological oxygen demand at some sites 3–10 days after the treatment. Dissolved oxygen then increased and concentrations were greater than they were prior to the treatment. Our results show that ProcellCOR has the potential to treat large infestations of yellow floating heart and that rapid plant decay resulted in only minor impacts on dissolved oxygen concentrations. Sentinel-2 satellite imagery can also be used to monitor the success of herbicide applications over large spatial and temporal scales.

Implementation of Various In-Lake Management Techniques to Address HABs in Lake Hopatcong, New Jersey

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

Lake Hopatcong, located in Sussex and Morris Counties, New Jersey, is the largest lake in the State. As a result of some large Harmful Algal Blooms (HABs) experienced over the 2019 summer season, the Lake Hopatcong Commission received a grant to implement a variety of near-shore in-lake management techniques to prevent, mitigate and/or control HABs. In addition to the grant funding provided by the New Jersey Department of Environmental Protection, a combination of in-kind and monetary contributions were made toward these HAB projects by the local municipalities, the Counties and the Lake Hopatcong Foundation.

These projects were initiated over the 2020 growing season and included applications of PhosLock, the use of Biochar for phosphorus removal, the use of a strong oxidizing algicide, upgrading some existing stormwater structures, the refurbishing and installation of Floating Wetland Islands and the installation of various types of near-shore aeration systems. Through the use of long-term and project-based water quality data, the relative effectiveness of these projects was assessed and will be presented in this presentation.

General Session 2E: Aquatic Invasive Species – Starry Stonewort

November 18, 2020 | 11:00 – 12:00

Effects of Large-Scale Management for Starry Stonewort (*Nitellopsis obtusa*) Using Chelated Copper and Mechanical Harvesting in a Minnesota Lake

Christine Jurek and Emelia Hauck Jacobs
Minnesota Department of Natural Resources, Sauk Rapids, Minnesota

Nitellopsis obtusa (starry stonewort), an invasive macrolage, was first discovered in Minnesota in Lake Koronis, Stearns County in 2015. Small-scale pilot project treatments were implemented prior to 2018; after which, the focus shifted to lake wide management using a combination of chelated copper (Cutrine® Plus) and mechanical harvesting. The impact of these lake-wide control methods for managing starry stonewort evaluated: 1) the effects of consecutive years of management on starry stonewort and native aquatic plants; 2) changes in biomass observed by method technique and 3) the impacts to bulbils following copper treatments. We detected a significant lake-wide increase of starry stonewort following management with declines in native aquatic taxa frequency. In management plots, starry stonewort frequency of occurrence resulted in no significant change in pesticide, mechanically harvested and combined management plots. In contrast, there was statistically significant decrease in starry stonewort biomass after both six- and eleven-weeks post-management for both pesticide and pesticide and mechanically harvested plots, although these declines were not significant after the second treatment. The mechanically harvested plot also showed significant declines before and after management. Results from the bulbil counts suggest that copper treatments had no detectable effect on bulbil density following treatments. This study demonstrates that biomass reduction can be achieved during a single growing season with repeated management, although the lack of significant reduction in the frequency of starry stonewort within a growing season and over multiple years may indicate that these control methods do not provide long-term control.

Containing the Spread of Starry Stonewort Using Handpulling and/or Copper Sulfate Products at Public Accesses in Four Minnesota Lakes

Steven McComas, Jo Stuckert, and Connor McComas
Blue Water Science, St. Paul, Minnesota

Starry stonewort (*Nitellopsis obtusa*) is an invasive macroalgae that was first observed in Minnesota in 2013. In four lakes where starry stonewort (SSW) was discovered at the public access, attempts were made to stop the spread to the rest of the lake. Control efforts at the sites of new infestations used three management techniques including hand pulling (1 lake), copper sulfate products (2 lakes), and a combination of hand pulling and copper sulfate applications (1 lake). The treatments were conducted 3 to 5 times from June through September in areas ranging from 0.6 acres to 1.5 acres. Based on lakewide meander surveys (at least 2 per year) combined with focused meander surveys (up to 5 per year), no SSW outside of the treatment areas has been found. Using these approaches SSW has been contained within the public access area for the last 4 years but has not been eliminated.

#Starry Trek: A Citizen Science Enterprise in Aquatic Invasive Species Early Detection

Megan M. Weber[1], Daniel J. Larkin[2], and Patrick Mulcahy[2]

[1]University of Minnesota, Andover, Minnesota; [2]University of Minnesota, St. Paul, Minnesota

Starry Trek is a Bioblitz-style style search for starry stonewort, a new invasive aquatic alga in Minnesota. It has been held annually in coordination with a sister program in Wisconsin, AIS Snapshot Day. Since its launch in 2017, participation has grown each year. With over 200 volunteers participating statewide each year it has allowed for the systematic search of over 200 public water accesses annually. Volunteers participating in Starry Trek have been responsible for the early detection of three previously unknown populations of starry stonewort (nearly one quarter of the known populations in the state). These early detections are critical for cost-efficient and effective management of this species. The population discovered by volunteers in Grand Lake (Stearns County, Minnesota) in 2017 was limited to a patch the size of a tabletop. Early detection has allowed for management using hand pulling, without the need for chemicals, which has been successful in limiting the population to the area it was first discovered. During this session, we'll discuss how we started up this new program in 2017, how we organize the statewide event, what our volunteers have discovered, as well as the management implications of events like this and how its growing and making a difference in Minnesota.

General Session 2F: Assessing HABs Through Paleolimnology

November 18, 2020 | 11:00 – 12:00

*Paleolimnological Reconstruction of Harmful Algal Blooms in Texas Reservoirs

Lane Allen[1], Victoria Chraibi[1], Katie Maryak[2], and Jeff Brady[2]
[1]Department of Biological Sciences, Tarleton State University, Stephenville, Texas; [2]Texas A&M AgriLife Research, Stephenville, Texas

Harmful algal blooms are being reported more frequently in Texas reservoirs, but it is unclear how long this trend has been developing in water bodies less than 150 years old. This study employed paleolimnological methods to retrieve sediment cores from three reservoirs in Texas, two of which are situated on the Brazos River and have recently reported harmful algal blooms caused by cyanobacteria or *Prymnesium parvum*, including a fish kill in 2020. Sediment characterization shows different depositional environments among all three basins. Diatom subfossil records indicate high biodiversity at Possum Kingdom Lake, but in all three reservoirs poor preservation at depth. Sediment DNA in a short core from Possum Kingdom Lake was analyzed to identify the presence of cyanobacteria and measure relative abundance as a proxy of bloom events. At points where peak abundance was observed, further genetic analysis for algal toxins will aim to identify whether or not those blooms became harmful. Understanding long-term trends in algal community structure can aid in creating models to predict harmful algal blooms for lake management.

*A Paleolimnological Perspective on Increased Cyanobacterial Bloom Occurrence in Three Mile Lake, Muskoka, Ontario

Elizabeth Favot[1], Kathleen Rühland[1], Andrew Paterson[2], and John Smol[1]
[1]Paleoecological Environmental Assessment and Research Laboratory (PEARL), Department of Biology, Queen's University, Kingston, Ontario, Canada; [2]Dorset Environmental Science Centre (DESC), Ontario Ministry of the Environment, Conservation and Parks, Dorset, Ontario, Canada

Cyanobacterial blooms have occurred annually following a major bloom and scum in the fall of 2005 in Three Mile Lake (TML), Muskoka, Ontario. Average open-water total phosphorus concentrations have increased from ~15 μg/L in the 1980–1990s to ~20 μg/L after 2000, while the region has experienced increasing air temperature, longer ice-free periods, and declines in wind speed. Collectively, these recent changes may promote cyanobacterial proliferation in TML. To ascertain baseline environmental conditions, natural variability, and potential changes in lake physicochemical properties that coincide with intensifying cyanobacterial blooms, we analyzed proxies in ^{210}Pb-dated cores from a dimictic and a polymictic basin of TML. We examined > 250 years of change in spectrally inferred chlorophyll *a*, cyanobacterial akinetes, diatoms, and chironomids. In both basins, increases in whole-lake primary production have occurred since ~1930. In the deeper thermally stratified basin, akinetes peak at ~1943, 1990, and 2007, suggesting cyanobacteria may have dominated decades prior to the 2005 bloom. Diatom assemblages underwent subtle shifts between planktonic *Discostella stelligera* and heavier, tychoplanktonic *Aulacoseira* taxa between ~1970–2005, with a mean increase of 10% in *D. stelligera*. In the shallower polymictic basin, a 30% decrease in Aulacoseira spp. occurred between ~1930–1995, concurrent with increases in several benthic and pennate planktonic taxa, and colonial scaled chrysophytes. We hypothesize that these changes indicate longer and warmer ice-free periods, reduced regional wind, and changes in lake turbulent mixing and thermal properties. These algal trends are supported by chironomid-inferred end-of-summer hypolimnetic oxygen, which reveals extremely low concentrations in the past two decades, coincident with cyanobacterial blooms.

*Long-Term Cyanobacterial Dynamics From Lake Sediment DNA: Relationships With Experimental and Environmental Change

Hebah S. Mejbel and Frances R. Pick
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In recent decades, cyanobacterial blooms in both fresh and marine waters have been affecting ecosystems and human health, in addition to causing regional economic losses. The relative impacts of climate change, nutrient loading, and other stressors remains unclear due to a lack of long-term records. The analysis of lake sediment archives can help address such questions. This study analyzed sediment DNA extracted from selected lakes at ELA, where various anthropogenic drivers have been manipulated and phytoplankton changes tracked over the past 40 years. We aimed to determine whether sediment cyanobacterial abundance, determined through the quantification of cyanobacterial 16s rRNA genes (ddPCR), is correlated with surface water records of abundance and whether selected taxa-specific gene copy numbers in sediments track the surface water records. Our sediment gene data show trends consistent with the ELA experimental treatments of nutrient additions and acidification. Eutrophied Lake 227 has seen more than a full order of magnitude rise in cyanobacterial abundance compared to reference lakes. Acidified Lake 223 experienced an increase in cyanobacteria during the acidification period but have subsequently recovered to reference lake levels. Sequencing of cyanobacterial 16S rRNA will provide additional information on community changes. The results obtained from this research study can be used to analyze other freshwater ecosystems impacted by anthropogenic activities and climate change.

General Session 2G: Contaminants

November 18, 2020 | 11:00 – 12:00

Arsenic Mobility, Biotic Uptake, and Human Health Risk From Consumption of Aquatic Species in Contaminated Shallow Urban Lakes

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Arsenic contamination of lakes in the US has occurred as a result of mining, smelting, and its use as an aquatic herbicide. This carcinogen is mobilized from lake sediments during stratification and hypolimnetic anoxia in the summer, but in deeper lakes this often results in a spatial separation between dissolved arsenic and oxygen-requiring organisms, reducing the potential for biotic uptake. However, during periodic summer mixing events typical in shallow lakes, bioavailability of arsenic is enhanced when arsenic mobilized in near-bottom waters is mixed into overlying oxygenated waters where biota reside. Our previous work measured sediment arsenic concentrations of over 200 µg/g in Puget Sound lakes affected by the former ASARCO smelter, and significant bioaccumulation of arsenic in phytoplankton (up to 970 µg/g) and zooplankton (up to 80 µg/g) in contaminated shallow lakes. We have now quantified arsenic concentrations and associated health risks in human-consumed tissues of sunfish, crayfish, and snails from lakes representing a gradient of arsenic contamination and differing mixing regimes. We find an increased cancer risk and increased risk of non-cancer health effects for high-consuming populations harvesting aquatic organisms in arsenic-contaminated shallow lakes. Applying what we have learned in the Puget Sound area, we plan to expand our scope beyond the region with input from NALMS members.

*Trace Element Accumulation and Distribution in Two Turtle Species, *Malaclemys terrapin* and *Chelydra serpentina* in New Jersey, USA

Molly Hillenbrand[1], Meiyin Wu[1], Walter Goessler[2], and Xiania Li[3]

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Within an ecological community, trace elements can bioaccumulate and biomagnify up the food web, posing a significant threat to human health. Inductively Coupled Plasma Mass Spectrometry (ICPMS) was used to determine the total concentrations of arsenic (As), silver (Ag), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), selenium (Se), lead (Pb) and zinc (Zn) within muscle tissue, carapace, liver and adipose of diamondback terrapins and common snapping turtles. The objective of this study was to 1) quantify trace element accumulations in muscle, carapace, liver and adipose of the diamondback terrapins and the common snapping turtles; 2) identify tissue types that are prone to trace element accumulations; 3) Investigate effects of size, sex and location on trace element accumulations and 4) assess human consumption risks. The data collected from this study indicates that Ag, Cd, Cu, Hg, Se and Zn accumulated within the liver of diamondback terrapin and common snapping turtles. The highest mean concentrations of Co, Cr, Ni and Pb were found in the carapace of the diamondback terrapins and the common snapping turtles. In diamondback terrapins, As was found to accumulate in muscle tissues. Sex was found to have an impact on As, Hg and Zn accumulations within different tissue types of diamondback terrapins. Diamondback terrapin males were found to have higher concentrations of As within the carapace. Diamondback terrapin females possessed higher concentrations of Zn and Hg in muscle tissues and Hg in the carapace.

The Importance of Lake Characteristics and Land Use to Detecting Contaminants of Emerging Concern (CEC) in Minnesota Lakes

Richard Kiesling[1], Sarah Elliott[1], and Mark Ferrey[2]
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We tested how occurrence and total concentration of CECs are related to watershed and lake characteristics in Minnesota lakes using boosted regression tree (BRT) machine learning methods. CEC data collected from 113 Minnesota lakes were used to identify lake and landscape variables related to high detections (> 4 CECs) and high total sample concentrations (> 61.9 ng/L). A total of 31 explanatory variables representing lake characteristics, percent land use, and road density were used to develop models for two different spatial scales. Models were trained using 80% of the data and tested using the remaining 20% to verify observed patterns and determine model accuracy. Model results indicate that variables from a 500 m buffer are more explanatory for both number of detections and total concentration when compared to variables representing the entire lakeshed. Good agreement on variable importance was observed between the two models, but lake characteristics were more important for explaining number of detections and land use variables were more important for total concentration. Relationships between explanatory and response variables generally make sense for both models. For example, more irregular shoreline (*i.e.*, shoreline development) and more cultivated crops tended to be associated with higher probability of more detections and higher concentrations while increasing forest cover was associated with a decrease in detections and total concentration. Results indicate that understanding the watershed in the direct vicinity of lakes is important for understanding contaminant occurrence. Results can be used to prioritize future research on understanding the sources of contaminants in inland lakes.

Approaches Used by Microbial Communities From North Saskatchewan River Water for Biodegradation of Pentane-Asphaltenes Isolated From Diluted Bitumen

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Natural Resources Canada, CanmetENERGY Devon, Devon, Alberta, Canada

Asphaltenes precipitated from crude oils using nonpolar solvents like pentane include the most polar and highest molecular weight organic compounds in petroleum. Their limited solubility in water, along with the complexity of their molecular structure and surface properties, limits the ability of most microbes to biodegrade them. The main objective of this study was to determine the approaches by which native microbes from North Saskatchewan River (NSR) water are able to biodegrade pentane-asphaltenes isolated from diluted bitumen (DB), a heavy oil petroleum product prepared from Alberta bitumen. For this purpose, water and sediment from the NSR, as well as pentane-asphaltenes from Cold Lake Blend diluted bitumen (DB), were used. DB was the only carbon source for the microbial cultures during a four-month period. Microbial population densities were determined periodically using a water-soluble protein measurement method, and pure strains were isolated by streaking on agar plates. Three microbial strains capable of using asphaltenic-carbon were isolated, whose identities are being determined using 16S rRNA gene sequencing. Cell surface hydrophobicity and surface tension measurements suggest that the mechanisms used by these microbes to biodegrade asphaltenes involve cell surface modifications to membrane structures and biosurfactants production. This study suggests that the natural attenuation of resistant organic compounds in crude oils at fresh water spill sites may be improved by treatment with biosurfactants.

General Session 2H: Continuous Monitoring

November 18, 2020 | 11:00 – 12:00

Implementation and Utilization of Real-Time Sensor Data to Inform a High-Resolution Understanding of Watershed's Water Budget

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[1]Minnehaha Creek Watershed District, Minnetonka, Minnesota; [2]Hennepin County Emergency Management, Medina, Minnesota

The Minnehaha Creek Watershed District (MCWD) was established in 1967 to address flooding along Minnehaha Creek, which is located downstream of one of Minnesota's largest lakes, Lake Minnetonka. In 1979, in an effort to reduce flooding, MCWD constructed its first project, a regional control structure, known as the Gray's Bay Dam (Dam), which was built at the outlet of Lake Minnetonka where it flowed into Minnehaha Creek. Forty-one years after the Dam was built, its operation continues to be an integral tool for water management. However, record precipitation over the past six years has resulted in a need to reevaluate the tools used to inform the Dam's operations.

As rainfall has become more intense, it has become increasingly important to operate the Dam based off live watershed conditions versus static data or resource intensive modeling. In response, MCWD formed partnerships with the National Weather Service and Hennepin County Emergency Management to receive tailored weather forecasts and higher resolution rainfall data. However, understanding the watershed's real-time response was still lacking.

The installation of continuous water level sensors across MCWD was identified as an intuitive solution. While this data set would be valuable on its own, greater benefit would be achieved by layering in data collected by our agency partners. All of this data will continuously feed into a model that will provide MCWD tools to evaluate how forecasted events will impact water levels, quantify the impact of dam operations, and overall improve how the dam is operated during extreme weather events.

Columbia Basin Water Monitoring Collaborative and Open Source Data Platform: Developing a Collaborative Water Balance Model Approach to Expand the Water Monitoring Network in the Upper Canadian Columbia Basin

Kat Hartwig[1], Martin Carver[2], Greg Utzig[3], and Santiago Botero[2]
[1]Living Lakes Canada, Brisco, British Columbia, Canada; [2]Columbia Basin Water Monitoring Collaborative, Nelson, British Columbia, Canada; [3]North Kootenay Lake Water Monitoring Project, Nelson, British Columbia, Canada

Water resources are changing rapidly during a general and long-term decline in monitoring efforts. Pressing water resource issues at local and regional scales reflect a range of escalating pressures on resources and include climate impacts such as extreme precipitation, flooding, fire events and peak glacial melt. Site-specific reactive monitoring can never satisfy the myriad of data requirements for all local water issues. Variability in hydrologic response across the Columbia Basin is too great to be sufficiently understood based on current monitoring. Potential monitoring is effectively infinite but resources are limited. It is necessary to refocus in planning future monitoring to carefully allocate limited resources to meet multiple scientific objectives. Recommendations for a phased expansion of the water (and water-related) monitoring network of Canada's Upper Columbia Basin (UCB) include priorities for monitoring identified within a scientific framework that distinguishes hydrologic variability according to known variation in climate within the UCB. Within this broad framework of the UCB's 10 hydrologic regions, setting priorities is based on hydrologic and terrain characteristics, compelling scientific questions, and prevailing water resource issues. These considerations go beyond what is needed to serve the Columbia River Treaty and its renegotiation because the monitoring network must address and support a wider array of issues and activities. It takes into account the full range of variation of potential watershed response within the UCB while also emphasizing watersheds critical to biodiversity conservation, community sustainability, and ecosystem resilience in the face of climate disruption.

Exploring the Merits of Continuous Monitoring for Management Decisions in Lakes

Anne Wilkinson

Wenck Associates, Minneapolis, Minnesota

Continuous monitoring can fill data gaps that are imperative for lake and stormwater pond management strategies. Transitioning from conventional discrete sampling to continuous sampling can improve management decision making and save project maintenance and cost. Examples of continuous monitoring programs in urban and rural lakes and ponds will be discussed. In each example, I will compare the results and management decisions made based on the continuous monitoring data and the corresponding discrete samples. These examples include effects on scientific studies looking at drivers for harmful algal blooms, dissolved oxygen modeling results for internal loading studies, and alum application area and cost. In each case, the data gaps resulting from discrete sampling made a significant difference in study conclusions, management decisions and cost. Finally, I will discuss the applicability and accessibility of continuous monitoring programs for lake projects.

General Session 2I: Aquatic Invasive Species – Management

November 18, 2020 | 11:00 – 12:00

*Integrating Genetics and Herbicide Studies to Improve Watermilfoil Management Outcomes

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Aquatic plant stakeholders in the Upper Midwest increasingly recognize that Eurasian watermilfoil (including hybrids; EWM) is genetically diverse, and that strains can differ in their growth, spread, impacts, and herbicide response. Genetic assays to identify herbicide resistant individuals are a promising tool to reduce herbicide failures. However, the genetic basis of herbicide resistance is frequently unknown. In clonal weed species, like EWM, DNA fingerprinting could be a useful tool to identify known resistant versus susceptible clones that occur in multiple locations, without an immediate need for understanding the genetic mutation(s) conferring resistance. Previously, a clone was confirmed as resistant to the commonly used herbicide, fluridone, and a recent genetic survey in Michigan identified this same genotype (MG-237) in at least eight other lakes. We hypothesized MG-237 collected from different lakes would also exhibit fluridone resistance. However, MG-237 may have accumulated resistance mutations at different times in its spread across Michigan, resulting in fluridone resistant and susceptible MG-237 clones distributed in different lakes. We used an herbicide assay to test the response of several accessions, including MG-237 accessions from multiple lakes, to the Michigan operational rate of 6 ppb fluridone. Indeed, we found that all accessions of MG-237 exhibited resistance to 6 ppb fluridone. A second genotype (MG-377) was also resistant to 6 ppb fluridone. The rest of the accessions were found to be significantly reduced by 6 ppb fluridone. Our results illustrate how we are combining genetic survey and monitoring of EWM populations with herbicide studies to inform management. And, by prioritizing widespread strains to target for herbicide studies we can inform management on multiple lakes containing a given strain.

Emerging Strategies for Selective Management of Invasive Aquatic Plants in the US

Mark Heilman
SePRO, Carmel, Indiana

Integrated strategies for management of invasive aquatic plants in the US continue to be improved and range from expanded inspection programs to prevent introductions, enhanced methods for eradication of early-stage infestations, and a range of techniques for maintenance control of later-stage infestations. For more established infestations, new methods – commonly more optimized aquatic herbicide use – offer improved selective control of target invasive aquatic plants that favor native plant dominance and habitat restoration of invaded sites. From a wide-ranging national perspective, this presentation will review a continuum of emerging new strategies for the management of invasive aquatic plants – from prevention to direct control – for problem exotic plants including hydrilla, invasive watermilfoils, and several major regionally important weeds in the upper Midwest. The presentation will illustrate through recent project case studies how strategies have been developed and optimized through smaller-scale evaluations including published controlled studies leading to full-scale operational management with ecological and water use benefits.

Financial interest statement – The author of this abstract has a financial interest in the subject described. Author is Director of Aquatic Research for SePRO – the leading aquatic herbicide and algaecide manufacturer in the US. This presentation will include review of new SePRO technologies with minimal use of branding in a comprehensive, non-commercial technical overview of many methods including non-chemical approaches. Author is also the 2019–2020 President of the Aquatic Plant Management Society.

Legacy Herbicides in Lake Sediments Are Not Preventing the Growth of Submersed Aquatic Plants in Lake Istokpoga

Mark V. Hoyer
University of Florida, Gainesville, Florida

Stakeholders concerned about the lack of submersed aquatic vegetation (SAV, primarily hydrilla [*Hydrilla verticillata* (L. F.) Royale] in Lake Istokpoga, Florida, have hypothesized that legacy herbicides in sediments were the possible cause of reduced SAV growth for the past 3 yr. Bioassay experiments were conducted from sediments collected from nine stations located around Lake Istokpoga in areas identified by stakeholders in which hydrilla had previously grown. These were compared with sediments collected from three stations in similar Lake Tohopekaliga, Florida, where hydrilla was currently growing. Tomato (*Solanum lycopersicum L.*) seeds were germinated in sediments from all stations in both lakes and control soils. Bare-root tomato transplants (3.8 cm tall) planted in sediments from both lakes continued to grow and, when harvested, plant dry weights were similar to transplants planted in two control soils (pure sand and 1 : 1 ratio potting soil : sand). Hydrilla tubers were also planted in sediments collected from three stations in both lakes and control soils. Tubers germinated in sediments from both lakes and control soils, and the percentage of germination was not significantly different between lake sediments and control soils. Sediment samples from all nine stations in Lake Istokpoga were sent to laboratories for chemical analyses of the nine aquatic herbicides used in Lake Istokpoga during the past 10 yr, and all results were "nondetect." Sixty cores were collected from areas with a history of hydrilla growth in Lake Istokpoga, and no hydrilla tubers were collected, suggesting little or no propagules are present for resumed growth of this SAV. Bioassays and sediment analyses indicate that legacy herbicides are not the cause of the decreased abundance of SAV in Lake Istokpoga.

General Session 2J: Carp Management

November 18, 2020 | 11:00 – 12:00

Invasive Carp Management Research in Lake Nokomis Subwatershed

Tony Havranek[1] and Rachael Crabb[2]
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The Nokomis Subwatershed located in Minneapolis, Minnesota, contains a series of lakes and interconnected wetlands in an urban setting. Some of these waterbodies are listed as impaired for nutrients (phosphorous) due to both internal and external loading. The Minneapolis Park and Recreation Board (MPRB) received funding through the Minnesota Legislative Citizen Commission on Minnesota Resources to address common carp as a potential source of this impairment. The MPRB began this project in 2016 and completed it in 2019, focusing on building and understanding of the abundance and movements of carp within the watershed, while implementing elements of an integrated pest management plan.

This presentation will provide details on methodologies used, results of various data collection efforts, how and what management activities were implemented, and the success of implementation, as well as the development of the integrated pest management plan that was a result of this three year project and challenges that still need to be overcome to achieve long term goals related to the plan.

The author of this abstract has/have a financial interest in the project described.

Common Carp Feeding Aggregations: Responses of Invasive Carp and Native Fish to Corn Baiting

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Common Carp, *Cyprinus carpio*, is a globally invasive fish which have received decades of management research. Carp are benthic feeders and their omnivorous diet, especially seeds (*e.g.*, corn), may be unique among North American fishes. Here, we conducted an experiment in Long Lake (Rice Creek Watershed, Minnesota) to determine if corn is a species-specific bait for carp. We implanted over 1,200 fishes with passive integrated transponders (PIT) to detect their presence at corn baited sites. PIT tags were inserted into 458 carp and 877 native fishes (*e.g.*, 357 bluegill, 164 white suckers). Prior to baiting, ~ 3 fishes visited the site daily. Within 48 h of baiting, carp visitors increased 10 fold, while native fish practically disappeared. Overall, 164 (35.8% of tagged carp) unique carp were detected at the baited site, as opposed to only 6 unique native species. When considering all carp in the lake, we were attracting ~2,000 carp to the bait daily (~10% of the population daily). Unlike previous studies, most individual carp visited irregularly, indicating that carp may have unique personalities. In the summer 2019, we further explored social components (*e.g.*, network of carp affiliations) of carp feeding aggregations to gain insight into carp social dynamics. Our findings indicate that corn is a potent, species-specific bait, which can be used to induce large carp aggregations composed of lake-wide social networks. Corn baiting provides management options, including use of toxin-infused corn pellets to selectively control carp ("bait and switch") and use of nets at the baited site.

Lessons Learned From 47 Lake-Years of Harvesting Gizzard Shad to Improve Water Quality

Erich Marzolf, Steven J. Miller, John Higman, John Hendrickson, and Dean Dobberfuhl
St. Johns River Water Management District, Palatka, Florida

The St. Johns River Water Management District has used large scale harvest of gizzard shad in six Florida lakes to remove biologically available phosphorus (P), reduce sediment bioturbation and P recycling. The total harvest of 37.2 million pounds directly removed 306,814 pounds of P. This public-private partnership's cost-effectiveness is achieved as harvested fish are sold as bait. The District currently subsidizes the catch by $0.56 per pound. The District's direct P removal cost averaged $76.28/pound P over the past decade.

In 30,800-acre Lake Apopka, where annual shad harvests began in 1993, typical harvests remove approximately 1M pounds of shad, or roughly 30–40% of harvestable size stock. This harvest removes 8,200 pounds P, 23% of the annual external P loading target. Long-term monitoring indicates Lake Apopka's standing stock of gizzard shad is being maintained at levels > 70% lower than when the harvest program was started. In lakes Griffin and Denham, multi-year harvests reduced harvestable-size gizzard shad populations by greater than 75%. Following the harvests and external P load reductions there was a > 50% reduction in water column P, > 70% reduction in chlorophyll *a*, and 80% increase in Secchi depth in both lakes. In Lake Griffin sport fish populations have dramatically increased and large professional bass tournaments have returned. In Lake George, a 46,000-acre riverine lake, P loads leaving the lake were 6% lower than the load entering the lake during the commercial harvest periods. In addition, rotifer density declined while Cladocera density increased during the harvest months.

Integrated Pest Management for Common Carp – Using Herding Techniques to Mitigate Limitations to Traditional Removal Methods

Mary Newman[1], Anthony Havranek[1], and Maggie Karschnia[2]
[1]WSB, Saint Paul, Minnesota; [2]Prior Lake Spring Lake Watershed District, Prior Lake, Minnesota

The removal of common carp biomass is a critical component of an integrated pest management approach to improving water quality and ecological integrity in lake systems where carp populations are at a damaging level. Traditional removal methods such as seine netting can be effective but may be impossible or difficult due to the location of fish being targeted in relation to obstructions on the bottom of the lake, steep drop-offs, or other impediments. To mitigate these limitations WSB collaborated with The United States Geological Society (USGS), Prior Lake Spring Lake Watershed District (PLSLWD), and local commercial fishermen to deploy and apply fish herding techniques known as the modified unified method (MUM) for common carp in the Upper Midwest, USA. This presentation discusses WSB's initial deployment of the MUM in Nebraska for Asian carp species and the application to common carp in Minnesota waters with the collaboration of the PLSLWD.

General Session 2K: Modeling

November 18, 2020 | 11:00 – 12:00

A Bayes Net Model for the Prediction of Trihalomethanes Based on Source Water Quality

Kenneth H. Reckhow
Duke University, Durham North Carolina

A Bayes network can be thought of as a probabilistic graphical model with a series of nodes linked by arcs (arrows). In the Bayes network (BN), the nodes represent important system variables, and the arcs indicate relationships between/among the variables. Each node is characterized by a marginal or conditional probability distribution that expresses uncertain knowledge concerning that variable. The arcs between the nodes indicate conditional dependencies; variables that are not connected by arcs are conditionally independent. A Bayes net model was created using the EPA Information Collection Rule data to relate raw water (lake/reservoir) quality to disinfection byproducts in the treated drinking water. This Bayesian model is being expanded to include a nutrient loading and lake response model based on EPA lakes survey data, and a USGS SPARROW model for organic carbon loading. Ultimately, these combined Bayes network models will be applied to management decisions in a North Carolina reservoir. These decisions will encompass both land use and drinking water treatment options.

Forecast of Geosmin Concentrations in Reservoirs Using Artificial Intelligence Tools

Roger Scharf, David Austin, and Brendan Gladman
Jacobs, Minneapolis, Minnesota

Taste and odor (T&O) compounds are critical concerns for drinking water utilities. Geosmin and 2-MIB are principal T&O compounds. Concentration peaks are seemingly random, often a bad surprise. Predictive tools would greatly benefit design and operation of treatment for T&O. Clayton County Water Authority (CCWA) operates three reservoirs (Shamrock, Blalock, and Hooper) that receive tertiary effluent and supply drinking water treatment. In October 2018, a severe T&O event motivated development of artificial intelligence (AI) tools to quantitatively predict geosmin. Intent of AI tools for T&O management was (1) to provide insight into best operational practice of reservoir oxygenation or aeration systems and (2) to provide timely warning for water treatment operations. Training data set inputs draw upon a sensor array: an EXO2 vertical profiler in Blalock (DO, temperature, pH, ORP, conductivity, turbidity, fDOM, phycocyanin, chlorophyll); triplet sensors (CDOM, phycocyanin, chlorophyll) in Shamrock, Hooper, and at a watershed confluence at the Hooper inlet; and DO/temperature sensors at the bottom of Shamrock. Other data inputs include phytoplankton counts, and epilimnion/hypolimnion TP, Fe, and Mn. CCWA increased the geosmin and 2-MIB laboratory throughput to train AI tools.

A year of data allowed an 80%/20% split of data into training and model prediction tool sets. Hypolimnetic oxygen depletion rates in Blalock Reservoir was to be a key predictor of T&O. AI tools provided accurate concentration forecasts up to four weeks out, including peak events. These tools are promising for both reservoir and water treatment operations.

Aligning Water Allocation Guidance for Lakes With Instream Environmental Flow Recommendations

Michael Seneka[1], Lauren Makowecki[2], Zahidul Islam[1], and Andrew Paul[2]
[1]Water and Waste Policy, Alberta Environment and Parks, Edmonton, Alberta, Canada; [2]Fish and Wildlife Stewardship, Alberta Environment and Parks, Edmonton, Alberta, Canada

Many jurisdictions have developed guidance for environmental flow recommendations to provide a desired level of protection for aquatic ecosystems. While desk-top methods for calculating these requirements have been more common in flowing systems, standardized general advice for non-flowing systems (lakes and wetlands) has been less so. By their nature, lakes often have watershed and water body specific factors that make a desk-top methodology more challenging to implement uniformly across a jurisdiction. For example in Alberta's largely semi-arid continental climate, the ratio of watershed area to lake surface area is a key determinant in how levels fluctuate seasonally and over longer-term wet and dry cycles, as well as patterns of how often and for how long a lake will spill with an outflow to downstream. Alberta recently released the Surface Water Allocation Directive (Alberta Environment and Parks 2019), which built on the existing principles in A Desk-top Method for Establishing Environmental Flows in Alberta Rivers and Streams (Locke and Paul 2011). The directive provides updated regulatory guidance including brand new information developed for lakes and non-flowing water bodies. By aligning lake recommendations with riverine methods, the new directive is intended to provide for allocation and use of water by people and society while maintaining a high level of protection for the aquatic environment, where site-specific aquatic environment studies or watershed objectives have not yet been determined.

General Session 2L: Remote Sensing for HABs

November 18, 2020 | 11:00 – 12:00

Field Verification in Northern California of the Cyanobacterial Assessment Network (CyAN) Cyanobacterial Bloom Satellite Algorithms

Keith Bouma-Gregson[1], Randy Turner[2], Samantha Sharp[3], and Marisa Van Dyke[1]
[1]California State Water Resources Control Board, Sacramento, California; [2]San Francisco Estuary Institute, Richmond, California; [3]University of California, Davis, California

Satellite remote sensing of cyanobacterial harmful algal blooms (cyanoHABs) enables bloom monitoring at spatial and temporal scales effectively unattainable with field sampling. The joint-agency Cyanobacterial Assessment Network (CyAN) uses data from the multi-spectral Ocean and Land Color Instrument on Sentinel-3 satellites to estimate cyanobacterial abundances in the surface water of large lakes. These estimates are generated from two spectral shape algorithms centered at 665 and 681 nanometers. In the Western USA, less algorithm verification data has been collected compared to the Central and Eastern regions of the country. To assess algorithm performance in California, we collected field radiometry and chlorophyll *a* data in 2019 and 2020 from 4 waterbodies in Northern and Central California on 8 sampling dates on the same day that a Sentinel-3 satellite passed overhead. Sampling occurred in a range of bloom intensities with chlorophyll *a* concentrations ranging from 1 to > 50 μg/L, with blooms dominated by *Microcystis*, *Dolichospermum*, and *Gloeotrichia*. The spectral shape 681 algorithm had a positive correlation between field and satellite radiometry data (standardized major axis regression slope = 1.18 and r^2 = 0.63). In contrast, the spectral shape 665 algorithm was less sensitive and produced many non-detects, even in water bodies with elevated chlorophyll *a* concentrations (> 20 μg/L) that were dominated by cyanobacteria. We found the algorithms to perform well at high bloom concentrations but recommend more field verification to determine algorithm performance and detection limits at low bloom intensities. Satellites are well suited for early-warning bloom detection, therefore a robust understanding of detection limits and data uncertainty at low bloom concentrations is necessary.

Validation of Algal and Cyanobacterial Class Remote Sensing Retrievals for Harmful Algal Bloom Studies

Joseph Ortiz
Kent State University, Department of Geology, Kent, Ohio

A constant change for remote sensing studies of harmful algal blooms is the collection of sufficient field validation data to confirm remote sensing retrievals. Cloud cover often prevents coordination of field and remote sensing studies, leading to ambiguity of satellite retrievals.

This challenge can be addressed through the use of either moored or towed instrument packages. Moored instruments provide the advantage of continuous or near continuous time series for comparison with remote sensing measurements from cloud free images. Towed instruments provide an effective solution to the problem by gathering large quantities of data rapidly during coincident satellite or aerial overflights. Field operations in the Indian River Lagoon and on Lake Erie provide examples of how these two strategies can be used effectively to maximize the value of limited field operations. Moored instruments deployed in the Indian River Lagoon by the Ocean Research and Conservation Association (ORCA) provide valuable field observations when coupled with field validation data. In Lake Erie, for high speed sampling, we tested the feasibility of employing a multichannel fluoroprobe in for towed operations. The system sampled at 1.6 Hz, while towed at 10–12 knots collecting thousands of measurements of algal class, temperature, and towing depth for comparison with satellite retrievals of algal class from MODIS Aqua/Terra and Sentinel 3A/B OLCI. Satellite retrievals were based on the Kent State University spectral decomposition method using varimax-rotated principal component analysis (VPCA). Validation results indicate retrievals that capture 80% or more of the field validation variance.

General Session 2M: Cyanotoxins

November 18, 2020 | 11:00 – 12:00

Approaches to Mitigating Cyanobacteria and Associated Cyanotoxins

West Bishop
SePRO Research and Technology Campus, Whitakers, North Carolina

Cyanobacterial blooms are increasing in duration and intensity in all regions of the United States. Toxic cyanobacteria pose significant risks to the ecological system and human health due to the potential production of numerous types of toxins (*e.g.*, neurotoxins, hepatotoxins, dermatoxins). Humans and wildlife associated with the water are exposed to these toxins in many ways such food chain accumulation, water supply, aerosolization and recreational activities. Acknowledging the multiple toxins, both currently described and yet to be characterized, numerous exposure routes, and potential for significant impacts; direct management is critical if toxins are present. Often there are concerns over applying USEPA approved algaecides to these blooms due to the release (or potential) of these toxins.

Applied management is frequently restricted due to perceived risk of toxin release even though many toxins are already found in the dissolved state, will be innately released, and overall total toxin is a critical component of the exposure potential. Novel management approaches are needed to address these concerns and restore the uses of the water resource. The objectives of this presentation are to cover some approaches for mitigating toxic cyanobacterial blooms both proactively and reactively as well as how to directly mitigate associated cyanotoxins.

Combining Estimates of Nutrient Loading and Flushing Rate with Measures of Waterbody Morphometry to Examine Lake and Reservoir Susceptibility to Eutrophication in Selected Watersheds of the Eastern and Southeastern United States

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The US Geological Survey, combined estimates of nutrient loads and flushing rates with measures of waterbody morphometry in lakes and reservoirs to identify groupings of waterbodies with similar Secchi depths and concentrations of chlorophyll *a* and the cyanotoxin microcystin. Assessments were completed for 232 lakes and reservoirs having a surface area greater than or equal to 0.1 square kilometer in watersheds that drain to the Atlantic and eastern Gulf of Mexico coasts of the United States and in watersheds within the Tennessee River Basin. Waterbodies were categorized by type—natural lakes, headwater reservoirs, and downstream reservoirs—and were assessed independently. Recursive partitioning and the model-based boosting routine were used to create four-node regression trees to group waterbodies into five endpoints along from low-to-high measures of Secchi depth, and concentrations of chlorophyll *a* and microcystin according to shared nutrient loading, flushing rate, and morphometric characteristics. Trophic state designations were assigned based on the average value within each of the five endpoints. Using these partition trees, all waterbodies that drain to the Atlantic and eastern Gulf of Mexico costs of the United States and in watersheds within the Tennessee River Basin with available nutrient loading and waterbody morphometry were placed within one of the five endpoints with respect to Secchi depth and concentrations of chlorophyll *a* and microcystin. These placements will help determine which waterbodies are most susceptible to eutrophication and potential cyanobacterial harmful algal blooms and aid water-resources management in prioritizing lake and reservoir protection and restoration efforts.

Roles of Akinetes (Dormant Cells) in Cyanobacterial Blooms in Nutrient Poor Waters – Literature Review

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Recent occurrences of cyanobacterial blooms in oligotrophic waters has been drawing attention of lake stakeholders and researchers. Researchers from the Global Lake Ecological Observatory Network have been conducting a comprehensive review of existing literature to identify key cyanobacterial traits that contribute to bloom formation in nutrient-poor environments. This presentation focuses on potential roles of akinetes, or dormant cells, in heterocyte-forming cyanobacteria. Our literature review contradicts the popular concept that akinetes are the key mechanism that enables "warm-loving" cyanobacteria to overwinter in the sediment below cold water. Cold tolerance is achieved by akinetes as well as larger vegetative cells and trichomes, and certain non-heterocystous cyanobacteria have been reported to survive extended periods at ≤ 4 °C. Light, temperature, and nutrient availability appear to be the major drivers of akinete formation and germination, all of which are being altered by the changing climate. Establishment and alleviation of P limitation are well documented to trigger akinete formation and germination, respectively. N accumulation observed in some large oligotrophic lakes could potentially lead to more akinete formation in near shore locations where N:P was previously more balanced. In contrast, heterocyte formation may be promoted over akinete formation in lakes with some degree of N limitation. The timing and success rate of akinete germination appear to be the more direct determinant of bloom formation than the number of akinetes in the sediment. Greater light penetration in oligotrophic waters may be facilitating akinete germination and subsequent bloom formation.

General Session 2N: Nitrogen

November 18, 2020 | 11:00 – 12:00

Isotope Tracers in Nutrient Source Tracking (NST) of Nitrate, a Different Perspective of Surface and Groundwater Remediation

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Anthropogenic activity continues to stress nutrient balance in shallow groundwater systems, estuaries, wetlands and lakes causing both short- and long-term environmental consequences. Stormwater events mix and move massive amounts of water and nutrients into and out of urban and rural watersheds, this causes stormwater events to challenge natural and constructed biofiltration and stormwater treatment areas with differing amounts and types of contaminants. To determine the dominant mechanism(s) by which excess nitrogen pollution is removed through biofiltration; a field scale biofilter was constructed and tested under transient flow conditions to best mimic stormwater events. Stable isotopic results of dissolved nitrate from inflow, outflow and core extracted water samples, revealed that at least four different mechanisms were working to transform and ultimately remove nitrogen through the system. These results promote how isotopic data can be used to optimize biofiltration systems by giving insight into the internal mechanisms by which remediation is taking place. Since not all biofiltration systems can be constructed equally, isotopic data is proving to be a reliable way to monitor and assess biofilters and stormwater treatment areas, which may ultimately discharge into recreational and potable water resources.

The author of this abstract has a financial interest in the isotopic analysis described.

Positive Responses of Net Ecosystem Productivity to Increasing N:P Ratios in Experimental Lake Mesocosms

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Lakes in agricultural watersheds experience significant nutrient loading from fertilizer application that can often be characterized by high nitrogen-to-phosphorus (N:P) ratios. Despite high N loading rates, recent evidence indicates that N-limitation is ubiquitous in agricultural systems, likely due to rapid denitrification. There is significant interest in investigating the role of varying N:P loads in structuring phytoplankton community composition, but we still lack a framework for understanding how N:P loads may influence ecosystem process rates limited by stoichiometric imbalance; specifically, gross primary production (GPP), ecosystem respiration (ER), and net ecosystem productivity (NEP). We used sensor-based measurements of GPP, ER, and NEP in 17,000 L pond mesocosms dosed across a range of N:P ratios to observe patterns in these process rates with varying load ratios. Productivity was greater as total N and N:P increased, for all rates. We also identified a breakpoint in the relationship between mesocosm particulate N:P and NEP, with linear increases as N:P increased between 3 and 15 molar, whereas maximum NEP was similar between 15 and 35. Chlorophyll concentrations also increased with increasing mesocosm N:P. The relationship between nutrient concentrations and chlorophyll, GPP, and NEP were all stronger with total N compared to total P, suggesting N availability was driving productivity across all treatments. Our results provide experimental evidence that higher load N:P observed in agricultural watersheds increase algal biomass and primary productivity of receiving lakes.

General Session 3A: Cyanotoxins

November 19, 2020 | 11:00 – 12:00

*Clearly Contaminated: BMAA and Non-bloom Forming Cyanobacteria in Oligotrophic Lakes

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

Beta-methylamino-L-alanine (BMAA) is a widespread cyanotoxin that may pose health risks to humans and wildlife. Although most cyanotoxin research focuses on nutrient-rich systems that support persistent cyanobacteria blooms, BMAA is also prevalent in oligotrophic systems that are less often afflicted by visible blooms. As part of a larger effort to track the movement of BMAA through aquatic food webs, this study aimed to identify sources of BMAA in two oligotrophic lakes that lack surface blooms. Preliminary results suggest both lakes supported bloom-forming cyanobacteria genera in low densities. Fluorometric measurements of phycoerythrin (PE) could indicate an abundance of picocyanobacteria. However, baseline PE levels have not been established in Wyoming lakes, so additional analysis of picocyanobacteria is needed. Cyanobacteria biomass, as estimated by PE, was positively associated with BMAA ($p < 0.0001$) and was significantly higher in the benthic and littoral areas than in the pelagic zone ($p < 0.0001$). The community composition of the benthos differed significantly from that of the pelagic zone ($p = 0.005$). However, these differences appear to be driven largely by diatoms rather than cyanobacteria. Therefore, toxicity appears to be more strongly related to biomass than to community composition. While preliminary, these results suggest that non-bloom forming cyanobacteria are a significant source of BMAA in oligotrophic lakes in Wyoming. Based on these results, we can infer that BMAA production in eutrophic systems may be high even in the absence of surface blooms, as picocyanobacteria and non-bloom forming benthic cyanobacteria may be present in even higher densities in eutrophic systems.

#Factors Associated With Cyanobacterial Harmful Algal Blooms in New York State Lakes: Findings From a Statewide Citizen Science Monitoring Program

David Matthews[1], Kimberly Schulz[2], Anthony Eallonardo[3], Andrew Brainard[4], Stephanie June[5], Scott Kishbaugh[5], and Rebecca Gorney[5]
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Data collected from 168 New York lakes by the Citizen Statewide Lake Assessment Program (CSLAP) during 2012–2017 were analyzed to identify factors associated with cyanobacterial harmful algal blooms (CHABs) and elevated microcystin (MC) concentrations. CHABs and CHABs with high toxins (MC > 20 μg/L) were documented in 63% and 27% of the study lakes, respectively. CHABs occurred primarily during July–September and predominantly in shoreline areas. Microcystis sp. was the most common genus, identified in 94% of shoreline CHABs with high toxins. Although CHABs were most common in eutrophic lakes (n = 50), they also occurred in 15 oligotrophic (TP < 10 μg/L) and 41 mesotrophic lakes (TP < 20 μg/L). The presence of dreissenid mussels increased the probability of CHABs in lakes with low-to-moderate nutrient levels and in lakes with long fetches. Higher proportions of agricultural and developed land cover were also associated with increased likelihood of CHABs, presumably a reflection of increased anthropogenic nutrient loading caused by these land uses. Logistic regression modeling identified total phosphorus, pH, northwesterly lake orientation, and the interaction between lake fetch and presence of dreissenid mussels as significant predictors of CHABs. The best overall model of CHABs with high toxins was based on total nitrogen, pH, northwesterly lake orientation and the interaction between lake fetch and presence of dreissenid mussels. Classification analysis indicated that CHABs were most common in hypereutrophic lakes (chlorophyll *a* > 22 μg/L) and less productive lakes invaded by dreissenid mussels.

Ecological HAB Control

Jonathan Todd
Eco Lake Solutions, Westlake Village California

East Lake in Yorba Linda, California is a 15-acre lake surrounded by 191 homes and a large clubhouse. In 2013 East Lake contracted Gold Algae (*Prymnesium parvum*), a harmful algae resulting in a total fish kill. Copper sulfate was applied to treat the infestation though minimal improvements occurred leaving the lake in a condition unable to sustain a healthy fish population. Similarly, at Lago Santa Margarita, *Prymnesium parvum* had decimated the fish population. Eco Lake Solutions implemented a two-pronged strategy, beginning with Floating Wetlands. Floating Islands provide the matrix for beneficial plant root ecology. In this aerobic zone, the water is flushed through the roots of the plants and the associated beneficial bacteria. Observations have been made that during golden algae blooms fish move towards highly aerobic areas, where these floating islands would provide a safe haven for them. High efficiency aeration is the second component and creates "hydraulic flushing manipulation." This strategy has been proven successful in studies at Texas A&M Department of Wildlife and Fishery Science and Oceanography. At East Lake, using highly efficient aeration systems we are able to achieve the required flushing rates using three, 0.5 horsepower piston compressors with each unit pushing 12.5 million gallons per day though the treatment zones. Our hypothesis is not that the floating wetlands up-take the nutrients that cause the algae bloom. Rather the flushing of lake water through the healthy ecology of the root zones, associated periphyton and beneficial bacteria creates an alternative ecology that is able to out compete or displace the HAB or golden algae dominant environment.

Three years ago, Eco Lake Solutions installed a pilot in the eastern section of East Lake to manage golden algae in that pilot zone. The pilot was significantly more successful than expected in terms of improved water quality throughout the entire 15-acre lake. Since the installation of the natural ecological system, the lake has reported Golden Algae at non-detect and the aesthetics, odor and water quality have improved dramatically, and the fish population is thriving. At Lago Santa Margarita the fish population had been decimated by golden algae and nuisance algae causing odors and a high level of complaints from area residents. The installation of 22 islands and 11 diffusors was completed in December of 2018. In April 2019, the chlorophyll *a* concentration readings were half of that from April 2018 providing confidence to release fish in the lake in July of 2019. As of June 2020, the fish are healthy and recreational fishing has returned to the lake in addition to a marked improvement in the overall water aesthetics. Golden algae testing continues to come back at non detect and lake clarity is better than it has ever been according to longtime residents.

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

General Session 3B: Sentinel Lake Studies

November 19, 2020 | 11:00 – 12:00

Widening the Data Distribution Stream: How Minnesota's Sentinel Lakes Program Is Improving Data Access

Tim Martin[1], Casey Schoenebeck[2], and Shannon Flynn[3]
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The Minnesota Department of Natural Resource's Sentinel Lakes Program is a long-term ecological lake monitoring program that collects high frequency data across a range of trophic levels in 25 lakes across the state. We use the collected data to both gain insight into the processes occurring in these systems and investigate how physical, chemical, and biological changes affect them. This is a collaborative effort involving multiple organizations, each with their own areas of expertise, requiring the processing, management, storage and transfer of large amounts of data by and amongst these collaborators. Sentinel Lakes staff have worked with state IT staff to develop a framework for accomplishing these tasks using an efficient, standardized, and yet flexible approach. This framework centralizes data access without centralizing data storage while providing standardized table organization and metadata. Keeping the framework flexible allows us to add features in the future such as data visualization and distribution. Increasing data accessibility and ease-of-use will provide the opportunity to increase the efficiency, volume, and quality of research studies and management decisions based on these data.

A Decade of Monitoring and Understanding Systems Change

Casey Schoenebeck[1], Tim Martin[2], Will French[2], Lee Engle[3], and Jesse Anderson[4]
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Changes in temperature, precipitation, land use and invasive species are stressing aquatic environments. The Minnesota Department of Natural Resources in collaboration with the Minnesota Pollution Control Agency champion the Sentinel Lakes Program; a system level long-term ecological monitoring framework created to detect changes and better understand their mechanisms and resultant impacts. Since the inception of the program in 2008, monitoring the 25 Sentinel Lakes has provided a better understanding of these impacts including land use changes that have resulted in a stable state shift, invasive zebra mussel and spiny water flea impacts on the zooplankton community, and oxythermal habitat on pelagic cold water fish. This collaborative program has also created a platform to facilitate external research to explore topics beyond routine monitoring ranging from harmful algal blooms to microplastics. This presentation will highlight what we have learned over more than a decade of monitoring and provide a look toward next steps in long-term monitoring including data management and accessibility through a public facing data portal.

General Session 3C: Lake Sediment Assessments

November 19, 2020 | 11:00 – 12:00

*Sediment Particle Size Predicts Phosphorus Release: Empirical Data From Willow Creek Reservoir, Oregon

Sarah Burnet and Frank Wilhelm
University of Idaho, Moscow, Idaho

Here we present empirical evidence which supports our hypothesis that sediment particle size is reflective of potential phosphorus (P) release from lake sediments. This hypothesis was prompted by observations of high variation in P release rates in laboratory-incubated cores collected from different parts of a reservoir and the knowledge that internal loading of nutrients can significantly delay water quality improvements after reducing external P sources to aquatic ecosystems. We analyzed particle size, reactive P, and the abundance of binding sites presented by the presence of iron (Fe), manganese (Mn), and aluminum (Al) in the sediment to a depth of 10 cm from 30 cores collected from Willow Creek Reservoir, Oregon, USA. Reactive P was significantly related to particle size and Fe, Mn, and Al. We did not find differences in lake-wide raster maps generated by P release rates or those based on particle size. This suggests that sediment particle size, which is easily determined and relatively inexpensive, can serve as a surrogate for release rates from incubated sediment cores which is a comparatively more involved and expensive process. We also suggest that the approach of analyzing particle size can be used to identify 'hot spots' *i.e.*, areas that should be prioritized if in-lake or partial lake treatments to inactive sediment P release are being considered for restoration.

*Literature Review of Sediment and Nutrient Resuspension in Response to Waves and Wakes: Current State, and Missing Pieces – Directions for Future Research

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Cultural eutrophication is the greatest and predominant threat to the quality of the world's freshwaters. With the increasing popularity of recreational activities such as boating in affluent countries, nearshore areas may be experiencing increased disturbance from wakes which may be resuspending sediments and releasing associated nutrients. We undertook a meta-analysis that included more than 180 peer-reviewed articles to identify the main ideas emerging from research over the last 4 decades; from the physical dynamics of disturbance itself, through the factors governing sediment resuspension and nutrient release, to possible consequences on aquatic ecosystems. Our goal was to lay the foundation to understand the phenomenon of resuspension in response to surface waves (naturally-generated) and wakes (human-generated). A major finding was that the physics-driven aspects of particle resuspension were universal, while the dynamics of nutrient release were governed by biological phenomena and the ecology of the ecosystem itself. We identified several key 'missing' pieces – which included a dearth of studies that simultaneously measured shear stress, water velocity, sediment resuspension and nutrient release to adequately address potential consequences in nearshore areas in response to the increase in recreational boating that generates large volume and high momentum waves. This weakness must be rectified to provide policymakers with the science necessary to make meaningful decisions such as distances of 'no wake zones' near shorelines to protect the water quality of our aquatic ecosystems.

*Sediment Phosphorus Assessment of Two Urban Lakes

Alessandra Rossi, Meiyin Wu, and Kevin Olsen
Montclair State University, Montclair, New Jersey

Lake Hopatcong and Greenwood Lake are two popular recreational lakes in northern New Jersey and southern New York which have been included in the New Jersey State's 303(d) list of impaired waterbodies due to high total phosphorus (TP) levels since 2003 and 2004, respectively. Major contributions of phosphorus were documented as surface runoffs, septic systems and internal load from the lake sediment. Between 2014 and 2018, we surveyed the sediments of the two lakes and quantified TP and percent organic matter (OM) contents. Sediment TP samples for Greenwood Lake ranged from 0.56 g/kg to 9.57 g/kg with a mean concentration of 2.94 ± 2.11 g/kg, very similar to the mean TP of 2.99 ± 2.13 g/kg for Lake Hopatcong, ranging from 0.36 g/kg to 22.40 g/kg. Sediment OM content for Greenwood Lake ranged from 10.33% to 52.28%, with a mean value 26.50 ± 10.33%, while for Lake Hopatcong spanned from 0.69% to 98.61% and a mean of 36.86 ± 21.49%. Standard least squares analysis showed that the OM content was a statistically significant predictor for sediment TP concentrations for both lakes. In addition, depth of sample collection was a significant predictor of sediment TP for Lake Hopatcong. Sediment phosphorus analysis confirmed that both Hopatcong and Greenwood lakes are indeed nutrient rich waterbodies; strategies to control phosphorus loading are imperative to improve water quality.

General Session 3D: Anoxia

November 19, 2020 | 11:00 – 12:00

From Reservoir Anoxia to Marine Dead Zones: Encountering the Circular Economy at Large Scales of Remediation

David Austin
Jacobs, Mendota Heights, Minnesota

Marine dead zones are a growing problem worldwide. The cause is familiar. Nutrient pollution grows phytoplankton which settle, decay, and consume oxygen. Anoxia occurs in regions of stagnant water below the pycnocline.

Elimination of hypolimnetic anoxia has been a central concern of reservoir management for decades. Hypolimnetic oxygenation using linear diffusers can scale up to marine applications. Linear diffuser designs can deliver 100 tons O_2/km/d. In the Chesapeake Bay, the oxygen demand is 1,000 to 2,000 metric tons O_2 per day. In the Baltic Sea, it is probably 10,000 to 30,000 tons O_2 per day. Large scale does not preclude technical feasibility. Diffusers arrays would readily scale. Oxygen production and supply logistics draw upon highly mature industrial practice at requisite scale. Energy is the central feasibility issue at marine scales. Conventional production of liquid oxygen requires about 165 kWh/ton at a cost of $100 to $150/ton. The circular hydrogen economy creates an opportunity for oxygen supply. Membrane hydrolysis of water can draw upon wind or photovoltaic excess (curtailed) energy production. Oxygen is a waste product. Producing 10,000 tons O_2/d entails production of 1,250 tons H_2/d, which is about 3.6 million tons per year CO_2 emissions avoided if hydrogen replaces diesel fuel.

There is serious interest in adapting reservoir oxygenation technologies to remediation of marine dead zones. Policy commitments to green hydrogen production and the pressing need for remediation present opportunities to scale up what we know how to do in reservoirs and lakes.

Predicting Anoxia in Low-Nutrient Temperate Lakes

Jeremy Deeds[1], Aria Amirbahman[2], Stephen A. Norton[3], Douglas Suitor[1], and Linda C. Bacon[1]
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Absence of dissolved oxygen (anoxia) in lake hypolimnia can eliminate habitat for sensitive species and may cause sediment phosphorus release. Anoxia generally occurs in lakes as a result of decomposition of organic matter and can be exacerbated by high nutrient loads. In some low-nutrient lakes, basin morphometry and its effects on lake stratification may cause naturally occurring anoxia. This is especially important to consider in water quality assessments that are predicated on the comparison of observed conditions to an expected reference condition. To investigate this, we constructed a logistic regression model based on 213 Maine lakes to calculate the probability of a lake developing an anoxia area $\geq$ 10% of lake surface area using variables related to basin morphometry, lake strata, epilimnetic phosphorus, and dissolved organic carbon in low-nutrient lakes. The model uses maximum lake depth and the relative lake area under the top of the metalimnion as predictive variables. The model correctly predicted the anoxic condition of 84% of lakes from a validation dataset of 50 lakes. Adding phosphorus as a model variable produced a significantly different model but comparable prediction success rates. The model may be applied to higher-nutrient lakes by identifying lakes where internal loading issues may be intensified by naturally occurring anoxia.

Determining Actions Needed to Eliminate Metalimnetic Hypoxia in Green Lake, Wisconsin

Dale Robertson[1], Benjamin Siebers[1], Paul Reneau[1], Cory McDonald[2], Robert Ladwig[3], David Hamilton[4], and Stephanie Prellwitz[5]
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Green Lake is the deepest natural lake in Wisconsin, USA, with a maximum depth of 72 m. In the early 1900s, the lake was oligotrophic, with hypoxia only in the deepest part of the hypolimnion. Increased nutrient (phosphorus) loading, however, has caused the lake to become mesotrophic, with hypoxia also occurring in its metalimnion (metalimnetic minima). Routine sampling has been conducted since 2004 to document lake water quality and phosphorus loading to the lake, with more comprehensive sampling in the lake (including fall and winter sampling) and tributaries (other nutrients) in 2017–18 to better understand the factors driving the hypoxia. A combination of empirical and hydrodynamic water-quality modeling was used to describe the factors causing the degradation in lake water quality. The General Lake Model coupled to the Aquatic Ecodynamics modeling library (GLM3-AED2) was used to describe short-term changes in lake water quality and to understand the factors causing the degradation in water quality and formation of metalimnetic minima.

Results from the models indicate lower metalimnetic oxygen concentrations in years with increased productivity (higher chlorophyll *a* concentrations) and poorer water clarity, which result from higher external loading. GLM3-AED2 results indicate that external phosphorus load reductions of least 35% are needed to eliminate the occurrence of metalimnetic minima of less than 5 mg/L in over 80% of the years. Results from this study are being used to improve management plans for the lake and guide watershed efforts to improve water quality and reduce the metalimnetic minima in the lake.

General Session 3E: Aquatic Invasive Species – Zebra Mussels

November 19, 2020 | 11:00 – 12:00

*Do Zebra Mussels Decouple Optimal Oxygen Habitat Volume and Resource Availability?

Benton Fry[1], Nicole M. Hayes[2], Peter C. Jacobson[3], Lesley B. Knoll[4], and Heidi M. Rantala[5]
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Understanding the relationship between eutrophication-driven oxygen depletion and long periods of hypoxia is important to fisheries managers. However, few studies focus on the impact of invasive species, like zebra mussels that can drastically alter productivity, on oxygen depletion rates in lakes. We examined the effects of zebra mussels on volumetric hypolimnetic oxygen depletion (VHOD, g m^{-3} d^{-1}), the rate of oxygen decline throughout the summer, using data from the Minnesota Sentinel Lakes long-term monitoring program. We examined VHOD trends in lakes Carlos, Elk and Ten Mile over an eleven-year period, 2008–2018. Carlos and Ten Mile are large (10.5 and 5.3 km^2), deep (max depth 49 m and 63 m) mesotrophic lakes that were invaded with zebra mussels in 2008 and 2018, respectively. Elk is a smaller (1.2 km^2), deep (28 m) mesotrophic lake that is not invaded by zebra mussels. Dissolved oxygen and temperature profiles were collected monthly during the open water season in all three lakes. VHOD was estimated using volume-weighted linear regressions of oxygen concentrations during the summer stratified period and corrected for temperature. VHOD decreased sharply in Carlos (0.0847 to 0.0517 g m^{-3} d^{-1}) four years after the invasion of zebra mussels. Our data support the hypothesis that the invasion of dreissenid mussels leads to a decrease in VHOD. These results suggest that zebra mussels create an additional challenge for lake managers, balancing the mismatch between an increase in cold water fish habitat at the cost of lost productivity.

Seasonal Pumping as an Approach for Zebra Mussel Management for Water Transfers to Uninfested Water Bodies

Jennifer Koehler and Margaret Rattei
Barr Engineering, Minneapolis, Minnesota

Zebra mussels are an aquatic invasive species slowly spreading throughout freshwaters, disrupting the ecosystems, negatively impacting native species, and negatively impacting lake recreational uses. In lakes and water bodies throughout Minnesota and Wisconsin, it is estimated that about 2–3 percent of lakes are infested with zebra mussels based on data available from each state's Department of Natural Resources. Currently, regulatory agencies require zero transfer of zebra mussels with water transfers to uninfested waters. Traditional ways of managing zebra mussels in water transfer settings typically include filtration, ultraviolet (UV) treatment, or some combination of both. These approaches are very expensive to construct, operate and maintain and have some level of failure and risk of transfer.

During recent projects, Barr staff have successfully worked with regulatory agency staff to identify seasonal pumping during the non-reproductive season as an effective approach to preventing the transfer of zebra mussels. This approach is based on research and an understanding of zebra mussel life cycles, targeting pumping when veligers are not present and mussels will be in the adult stage, with neither being present in the water column. For some situations, seasonal pumping can be a more cost-effective approach to helping eliminate the transfer of zebra mussels. If pumping is required year-round, the approach can also be combined with other traditional methods to reduce annual operational costs and allow for periods of system maintenance.

General Session 3F: Partnerships for Lake & Watershed Management

November 19, 2020 | 11:00 – 12:00

*Using an Environmental Justice Lens for a Better Understanding of Environmental Governance Processes: The Case of Agriculture-Wildlife Management in Lac Saint-Pierre, Québec, Canada

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This research respectfully involves Indigenous communities. Floodplains are subjected to various pressures, where the coexistence between agriculture, biodiversity conservation, waterfowl management and water resources can be conflictual. This paper analyzes, through an environmental justice lens, how institutional arrangements set by actors coming from different governance levels shape cohabitation outcomes between agricultural activities and freshwater conservation in a given socio-ecological system. To do so, this work presents the case study of Lac Saint-Pierre (LSP) in Quebec, part of the St-Lawrence river basin, a territory where important tensions between agriculture, conservation and development are found. LSP is an exceptional site recognized by UNESCO and RAMSAR Convention for its biodiversity and unique character. In recent decades, LSP has undergone many changes in its floodplain, notably through the conversion of perennial crops to more intensive annual crops considered incompatible with aquatic life and current environmental policies.

Through qualitative data from various stakeholders' interviews, this research characterizes the overall institutional setting regulating the agricultural uses in LSP floodplains. The analysis identifies areas where improvement is needed to expand cohabitation amongst the users and mitigate the multi-factors environmental stressors surrounding LSP fish habitats and water quality from an environmental justice (distribution, participation, recognition and capabilities) perspective.

A Public-Private Regional Approach to Lake and Watershed Management

Chris Mikolajczyk
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 Council possess a professional staff of planners, science experts, geographic information specialists and administrative personnel. 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. These reimbursement-based grants are approved by the Council following the submittal of a scope of work.

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 the Fall of 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 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 will continue through the full growing season of 2020. The results of the assessment will seek to address both non-point source impacts (Township) as well as any in-lake based sources of impact (Private lake associations).

#Citizen Science Monitoring of Waters Flowing Into Lake Washington, Seattle

Gary Olson

Thornton Creek Alliance, Seattle, Washington

Thornton Creek is an urban creek in Seattle, which feeds into Lake Washington. It has a number of pollution related problems. Thornton Creek Alliance decided to get involved with initially gathering data about some of these problems with the hope of determining their sources and working with local agencies to improve the situation. Initially we met with experts in our community, who have done research on the creek, to determine how our resources could best be utilized. As a result of this effort we identified *E. coli* levels and also storm water runoff pollution as two areas of concern. We worked with Seattle Public Utilities (SPU), which has responsibility for the creek, to develop a sampling and monitoring scheme that would give SPU information to better understand *E. coli* levels at various location in the Creek. Over the last 3 years we have monitored over 36 locations on the creek and its tributaries for *E. coli* levels. We also have engaged four schools in the watershed to also do monitoring. During this presentation I will share how we operate as a citizen science group, the data we have accumulated and what it means.

We have also been doing storm water monitoring and this will be described, and some data presented.

The data is important, but a key message is that by getting the community actively involved in better understanding the water quality issues the better chance for improvement.

Arctic Lake Restoration

Jennie Sirota, Scott Walz, and Ole Olmanson

Shakopee Mdewakanton Sioux Community, Prior Lake, Minnesota

The Shakopee Mdewakanton Sioux Community and local partners have been key to the restoration progress at Arctic Lake, located in Prior Lake, Minnesota. Arctic Lake has been impacted by increased nutrient concentrations, low dissolved oxygen and invasive common carp. Improvements within and surrounding the lake have created steps towards our goal of improving water quality and lake habitat. Challenges remain and future restoration may require innovative solutions.

General Session 3G: Topics in Limnology

November 19, 2020 | 11:00 – 12:00

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*Water Security Level Prediction for Sustainable Development Objectives In Saskatchewan, Canada

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Industrial Systems Engineering, University of Regina, Regina, Canada

Recently, water has turned to be as a mutual treasure amongst human beings due to the increasing demand for water supplies in one hand and decreasing level of water resources, on the other hand. As an initial step to cope with the challenge of long-term water supply and demand stability in a sustainable and resilient way, measuring, analyzing, and forecasting of proper criteria are required to motivate policy actions. The objective of this paper is to identify and forecast the time series indicators of water security using grey prediction method. Results are presented from a time-series analysis of alternative indicators of water security unit in Saskatchewan province, Canada. The main contribution of this research is a prediction of water security level of Saskatchewan based on Grey theory, GM (1,1), considering variety of criteria, simultaneously. Based on availability of data, seven key performance indicators have been considered in this paper which are categorized under three perspectives of water consumption, quality, and risk. Final outcomes show that with what trend these criteria will be decreasing or increasing in future that can assist decision makers by providing the reliable information that they need to assess and forecast the level of water security of the province.

*Measuring Open Water Lake Evaporation at Upper and Lower Red Lake

Joshua Jones[1] and Miriam Rios-Sanchez[2]
[1]Red Lake Department of Natural Resources/Bemidji State University, Bemidji, Minnesota; [2]Center for Sustainability Studies, Bemidji State University, Bemidji, Minnesota

For the Anishinaabe people of the Red Lake Nation in Northern Minnesota there is a deep spiritual, cultural and economic connection to the water resources. Measuring and quantifying the water resources is integral to sustainable management to protect them for the future generations of the Red Lake people. With the advent of climate change it is even more important to establish a clear and reliable monitoring strategy for the water resources. Upper and Lower Red Lakes are hydrologically unique with regards to their large size and relative shallowness. Little research has been allowed on the lakes by the Red Lake Tribe so there are large gaps of knowledge while trying to estimate the water resources. One of the key components to a monitoring strategy is the creation of a water budget. A water budget aims to measure the rates of water movement and the change in water storage in all or parts of the atmosphere, land surface and subsurface. A water budget will help to calculate the balance of water coming in and going out of a watershed, and hence the changes in water stored for a given period of time. Evapotranspiration is one of the most important outfluxes in the water budget and is one of the most challenging to measure due to its dependence on local, regional and/or global factors. Moreover, evapotranspiration requires specific devices and accurate measurements of various physical parameters. One of the primary parameters for calculating a water budget for Red Lake is quantitative measurements of lake/open water evaporation. Open water evaporation estimates in Northern Minnesota have been done for deeper and smaller lakes. Using these data estimates to quantify evaporation of Upper and Lower Red Lakes would induce large errors in estimate of the outfluxes and the overall water storage. This study will attempt to accurately measure and quantify the open water evaporation for Upper and Lower Red Lakes, this will be conducted using a specialized weather tower to collect air temperature, humidity, wind speed/direction and net radiation. The collected data will be used with energy budget modeling to measure total lake evaporation and improve the calculations of the evapotranspiration in the watershed. Improving the quality of data for evapotranspiration will contribute to the calculation of a reliable water budget for the Red Lake Nation.

*Sentinel-2 Red Edge Bands Based Indices for Haloalkaliphiles Detection in India's Largest Saline Wetland During COVID-19 Lockdown

Rajashree Naik and L.K. Sharma

Department of Environmental Science, School of Earth Sciences, Central University of Rajasthan, Ajmer (Raj.), India

Emergence of COVID-19 has emphasized that destruction of ecosystem leads to destruction of human. Ecosystem that protects us have been altered allowing pathogens including corona virus to disrupt. Wetlands are diverse ecosystems in which slight alteration puts enormous impact on whole ecosystem. India had lockdown from 24 March to 30 May 2020. Current study estimates change in haloalkaliphiles of India's largest inland saline Ramsar site Sambhar Salt Lake through remote sensing data, in the absence of ground observations. Saltpan encroachment, lake shrinkage and migratory birds reduction are major threats. Sentinel 2A/B imagery were used for True and False Color Composites of 2019 and 2020 to compare pre and post COVID-19 lockdown scenario. Results state increase in haloalkaliphiles during lockdown. Further, vegetation Red Edge bands (B5, B6, B7, and B8A) were used in Surface Algal Bloom Index instead of red band (B4). Comparative results state Red Edge Band 05 (705 nm) has highest efficacy for detection of haloalkaliphiles and chlorophyll estimation of a saline lake. Results were correlated with the literature establishing viral-algal interrelationships for *Chlorophyceae*, *Cyanophycea*, *Bacilariophyceae* and *Eugleanophyceae*. Increase in haloalkaliphiles is for more migratory birds this year.

*Characterization and Management of an Historic Reservoir: Beaver Lake, Monticello, New York

Cindy Sosa

SUNY Oneonta Biological Field Station, Cooperstown, New York

Beaver Lake lies within the summer vacation resort, Beaver Lake Estates located in Monticello, Sullivan County, New York. Stakeholders of the Beaver Lake community have voiced concerns about plant overgrowth specifically, vascular macrophytes: White Water Lily (*Nymphae odorata*) and Water-shield (*Brasenia schreberi*), impeding recreation. There has been no previous monitoring of the ecosystem or data collection in the past so very little was understood about the waterbody and its environment prior to this study. Lake monitoring in the reservoir began in September of 2019. Various water quality parameters, such as temperature, dissolved oxygen, water clarity, chlorophyll *a*, and nutrient concentrations were measured and analyzed. Biota within the system were also identified to better understand the ecology of the system. Furthermore, information found on various government and online sources was compiled to characterize the current state of the lake. The study is ongoing and future work, such as the creation of a bathymetric (depth) map is pending to better understand the morphometry of the lake. This study aims to provide baseline information about the reservoir that will enable stakeholders to begin addressing common concerns through potential management strategies with an issue-based management plan as a deliverable.

General Session 3H: Nutrient Sources

November 19, 2020 | 11:00 – 12:00

Investigating a Land – Lake Disconnect: Are Climate and Invasive Species Altering Nutrient Loading Pathways and Our Lake Management Strategies?

Brian Ginn

Lake Simcoe Region Conservation Authority, Newmarket, Ontario, Canada

Lake Simcoe, the largest inland lake in south-central Ontario (Canada), has experienced environmental issues synonymous with eutrophication since the 1960s: low hypolimnetic dissolved oxygen (DO), recruitment failure in coldwater fish species, elevated phosphorus (P) concentrations, and increased algal / aquatic plant biomass. Additionally, the lake has been affected by invasive dreissenid mussels and climate change. The current lake management strategy, started in 2009, set restoration targets of minimum DO = 7 mg/L, which relates to a phosphorus loading of 44 tonnes/yr. Over the past decade, this strategy has been partly effective with a current minimum DO = 6.2 mg/L (2014–2018) and lakewide mean spring TP = 7.3 µg/L (2014–2018). However, P loading has fluctuated above the 44 tonne target, driven mainly by extreme rainfall events in summer, rainfall on frozen ground during winter, and increased tributary flow volumes. For the past five hydrologic years (June 2013 to May 2018) P loading has averaged 93 tonnes, with a peak of 131 tonnes in 2017–18.

Typically, in lake systems, P loading drives in-lake P concentration and hypolimnetic DO. However, in Lake Simcoe, there is an apparent disconnect between the quantity of P inputs and in-lake conditions. We are investigating the cause of this anomaly by exploring: climate, has changing patterns of precipitation and tributary flow altered how P is delivered to the lake, either by amount, or timing?; or have invasive species (*i.e.*, dreissenid mussels and starry stonewort) re-structured how P is stored, cycled, and used in the lake.

A Hidden Source of Phosphorus Loading; The Eutrophication Impacts of Tap Water on Lakes

Stephen J. Souza[1] and Alan Fedeli[2]

[1]Clean Waters Consulting, LLC, Ringoes, New Jersey; [2]New Jersey Coalition of Lake Associations, Ringwood New Jersey

Successful lake management necessitates controlling phosphorus loading, which in turn entails the identification and accurate quantification of all phosphorus sources. One source that is rarely considered is the water obtained from potable water utilities. For urban and suburban lakes this can be a significant, "hidden" source of phosphorus loading.

The human health impacts of lead and copper in drinking is well documented. The primary source of this lead and copper contamination is pipe corrosion. The corrosion control plans implemented by water treatment plants often involve adding a corrosion inhibitor to the "finished water"; the most common products being orthophosphates and zinc phosphates. Orthophosphate treatments date back to the late 1800s, but have increased over the past three decades. Typical orthophosphate treatment concentrations can range from 0.5 to 1.0 mg/L. This treated tap water may be used to irrigate lawns and ornamental vegetation. This may also increase the septic related phosphorus loading. Such uses peak in the summer, setting the stage for added phosphorus loading at that time of year when algal productivity is at its greatest. As a result, we may be unknowingly promoting algal blooms, including HABs.

This presentation discusses a New Jersey lake community's discovery of alarmingly high concentrations of phosphorus in their tap water and the implications of this loading on their long-term lake management efforts. The presentation will review measures that can be taken to mitigate such loading, including the use of alternative silicate-based additives to control pipe corrosion and lead/copper contamination.

Stormwater Pond Management for Phosphorus Retention

Vinicius Taguchi[1,2], William Herb[1], John Gulliver[1,2], Jacques Finlay[1,3], and Ben Janke[1,3]
[1]St. Anthony Falls Laboratory, University of Minnesota, Minneapolis, Minnesota; [2]Department of Civil, Environmental, and Geo- Engineering, University of Minnesota, Minneapolis, Minnesota; [3]Department of Ecology, Evolution, and Behavior, University of Minnesota, St. Paul, Minnesota

Watershed management has long relied on urban stormwater ponds to capture and retain phosphorus as a load reduction strategy for sensitive downstream waterbodies. Yet, internal loading in these ponds may inhibit phosphorus capture over time and result in reduced phosphorus capture or even phosphorus export to receiving waterbodies. Internal loading is well studied in lakes and reservoirs, but little is known about how to design and manage stormwater ponds to minimize internal loading. We developed a mechanistic computational model in CE-QUAL-W2 to better understand the controlling factors of phosphorus retention in ponds and assess potential operation and maintenance strategies. By combining field monitoring data from stormwater ponds with monitoring and modeling data from the literature, we assessed the impacts of wind sheltering from overgrown trees, stratification from winter chloride applications, artificial aeration, and potential alterations to pond outlet design on phosphorus retention. Current inspection and maintenance methods to verify, and hopefully ensure, stormwater pond phosphorus retention are time- and resource-intensive. By evaluating factors that affect pond phosphorus retention, we can inform the development of treatment and remediation strategies for ponds and estimate their potential effectiveness in a cost-effective manner. This presentation will discuss the modeling results and make recommendations for pond management based on the integration of field measurements and modeling.

General Session 3I: Bacteria and Pathogens

November 19, 2020 | 11:00 – 12:00

Pathogen Task Force – Team Work Makes the Dream Work!

Shahram Missaghi[1] and Nicolas Cantarero[2]
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Bacteria and pathogens are the most frequent cause of water quality impairment in the US. In Minnesota, there are over 350 stream stretches and beaches impaired for bacteria. The behavior of bacteria and pathogens in the environment is complex. Levels of bacteria and pathogens in a body of water depend not only on their source, but factors such as weather and water temperature. Testing for specific disease-producing bacteria or other pathogens (viruses, protozoa, etc.) is difficult, expensive, and time-consuming. Consequently, fecal coliform and *E. coli* bacteria are often used as "indicator organisms" to denote the potential presence of fecal waste. The City of Minneapolis recently completed a comprehensive study on the sources, pathways, and potential impacts of *E. coli* bacteria in Minnehaha Creek. The goal of the study was to better understand potential causes of impairment to the creek and guide future City projects to reduce bacteria concentrations. In February 2020, the City hosted a work session with partners and stakeholders to share the results of this study and develop a framework to prioritize stormwater practices for pathogen reduction and monitoring. The group recommended forming a pathogen task force. The task force includes representatives from state and local governments and consulting firms.

In our presentation we will focus on three priority areas for the task force. For permit compliance, we will discuss flexible performance-based approaches that incentivize permittees to focus on source identification. This links directly to monitoring, where we discuss the use of techniques such as molecular markers, microbial community analysis, and direct measurement of pathogens instead of indicator bacteria. Finally, we will discuss the goals for the task force in identifying effective stormwater management practices, including both structural and non-structural practices.

A Scalable Approach to Identifying All Fecal Sources of Contamination in Watersheds

Take Ogawa[1] and Gary Andersen[2]
[1]Veracet, Inc., Berkeley, California; [2]Lawrence Berkeley Lab, Berkeley, California

Sources of fecal indicator bacteria are difficult to identify in waterways where many different nonpoint sources may be responsible for contamination throughout the watershed. We developed a customizable microarray-based test based on the PhyloChip platform that detects and distinguishes fecal bacteria from humans, birds, dogs and cats, ruminants, horses, pigs and non-fecal environmental sources with a single assay.

The probe-based microarray test was applied to identify sources of fecal indicator bacteria in the Russian River and its tributaries. We found contamination by human sources during the wet season in lower reaches of the Russian River, due to failing septic systems in two separate communities. In addition, heavy recreational use in the dry season also caused human fecal contamination, likely due to bacterial shedding from beachgoers. Several samples that clearly contained human fecal bacteria did not exceed water quality thresholds for conventional FIB tests, some of which contained numerous Staphylococcus and other potential bacterial pathogens. These results indicate that conventional tests used for monitoring may fail to detect potential risks from fecal contamination and are less sensitive than detection based on thousands of molecular targets. All potential sources can be detected simultaneously, including sources for which no known or reliable markers exist. Additional applications include the addition of viral sequence-specific probes for community surveillance of potential pandemics in wastewater.

Disclosure of financial interests: Veracet, Inc.

General Session 3J: Lake and Watershed Assessment and Classification

November 19, 2020 | 11:00 – 12:00

Shoreland and Shallows Habitat Assessment Protocol: A New Tool for Lake Quality Assessment and Identifying Problem Areas

Reesa Evans
Lake Ecological Services, Adams, Wisconsin

In 2012, the National Lakes Assessment concluded that the biggest challenge to lake management was the alterations of shoreland and shallows habitat, finding that lakes with poor lakeshore habitat were three times more likely to have poor biological health. An earlier study by other researchers had found that as lakeshores development increased, habitat for fish and wildlife decreased and even disappeared. In response, Wisconsin developed a Shoreland and Shallows Habitat Assessment tool that could be correlated to habitat health, but also could be used to identify potential problems areas for runoff and erosion. This presentation outlines the steps in this assessment and compares the results of using this tool on ten Wisconsin lakes, some of which are man-made and highly developed and some of which are natural and less well-developed, then compares those results to water quality testing over the last twenty years. It also explains how, using this tool, lay people can gather the data necessary for making lake management decisions.

Rethinking Vermont's Trophic Status Index

Leslie J. Matthews[1], Kellie Merrell[1], Oliver Pierson[1], Betty J. Kreakie[2], Jeffrey W. Hollister[2], and Stephen D. Shivers[3]
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Trophic Status Indices (TSIs) typically classify lakes into discrete categories from across a continuum of biological productivity. Such indices are valuable tools for developing lake management and protection strategies. The Clean Water Act (§ 1324) requires that states classify their lakes according to trophic condition biannually. Vermont's current Trophic Status Index (TSI), based on phosphorus, chlorophyll *a* concentrations, or Secchi disk transparency, has significant limitations. First, Vermont lacks data for all three of these parameters for many lakes. Second, these parameters often lead to contradictory classifications when considered individually. Finally, Vermont's classifications frequently fail to coincide with other TSIs or with lake scientists' and managers' professional best judgements about lake trophic condition. To create an improved TSI for Vermont, we applied the proportional odds logistic regression (POLR) model described by Nojavan *et al.* (2019; Rethinking the lake trophic state index; PeerJ, DOI 10.7717/peerj.7936) with chlorophyll *a* as the response variable, and predictor variables previously selected by Nojavan *et al.* using random forests. For each lake, the model calculates the probability that the lake belongs in each of four trophic classes (oligotrophic, mesotrophic, eutrophic or hypereutrophic). Each lake is then classified according to the trophic condition with maximum probability, which also provides a measure of confidence for the classification. The model appeared to correctly classify most Vermont lakes, however maximum probabilities for most lakes only ranged from 50–65%. Methods to improve classification confidence, including random forest selection of Vermont-specific predictor variables and consideration of other lake productivity response variables are being investigated.

WWF-Canada's Watershed Reports

Catherine Paquette[1], James Snider, Elizabeth Hendriks[2], and Anthony Merante[2]
[1]WWF-Canada, Ottawa, Ontario, Canada; [2]WWF-Canada, Toronto, Ontario, Canada

In 2017 WWF-Canada completed the first national assessment of the country's watersheds, looking at both the health of and threats to Canada's freshwater. These two assessment frameworks – collectively known as Watershed Reports – provide a standardized basis for evaluating the health of and threats to Canada's waters. Based on these findings, Canada's watersheds are facing a series of significant threats, particularly pollution, habitat fragmentation and habitat loss. The results also reveal a pronounced lack of available and accessible data, leading to data deficient health scores. These results and key learnings were condensed into recommendations, which include steps on improving the collection, analysis and sharing of data. One of these recommendations was that standardized freshwater assessments should be conducted every three to five years (ideally by government), in order to maintain a current and representative picture of health conditions. In September 2020, WWF-Canada will release new assessments for each of Canada's 25 watersheds, incorporating new data as it becomes available. This presentation will dive into these new results, highlight key findings and next steps.

General Session 3K: Climate Change

November 19, 2020 | 11:00 – 12:00

#Climate Change Impacts to Rhode Island Lakes and Ponds

Elizabeth Herron[1], Linda Green[1], and Arthur Gold[2]
[1]University of Rhode Island Cooperative Extension, Kingston, Rhode Island; [2]University of Rhode Island Department of Natural Resources Science, Kingston, Rhode Island

URI Watershed Watch (URIWW) and its volunteers have produced over three decades of comprehensive data for lakes and ponds in Rhode Island, creating a valuable dataset allowing trends to become apparent. While land use and other changes have occurred throughout those decades, climate change seems to be a larger driver for increases in productivity, measured as chlorophyll, in many lakes and ponds. This presentation will review some of those impacts, highlighting the value of long-term data sets and the engagement of volunteers in generating credible water quality data. Further it will share information on available data resources for additional research opportunities.

*Life History of a Lentic Caddisfly in Coeur d'Alene Lake

Elizabeth Hoots[1], Ben Scofield[2], and Frank Wilhelm[1]
[1]University of Idaho, Moscow, Idaho; [2]Coeur d'Alene Tribe Lake Management Department, Plummer, Idaho

The current trends in global climate have the potential to affect rates of processes across all ecosystems and organisms. Water bodies are among the most affected ecosystems, warming at rates greater than the surrounding terrestrial landscapes. This will fundamentally alter underlying basic temperature-mediated processes and interactions among organisms. In the Pacific Northwest region of the United States, Coeur d'Alene Lake is not exempt from these trends. We investigate how predicted future changes in water temperature will affect the physiology of the lentic case-building caddisfly, *Nectopsyche albida*.

We collected 5th instar larvae from Chatcolet Lake at the southern end of Coeur d'Alene Lake to quantify the duration of their pupal life stage at different temperatures (20 °C, 30 °C). We used additional instars to study the caddisfly's rate of biomass accumulation, measuring the head capsule and case length, and the total dry body mass. Because their cases cease growing in the winter, these findings, in combination with future winter surveys, will help us understand how much *N. albida* grows when most macrophytes are senescent. In combination with climate predictions for northern Idaho, we describe the potential future life cycle timing of the caddisfly to provide insights into trajectories of the larger Chatcolet Lake ecosystem by comparing the changing timing of the *N. albida* life cycle with the growth of native and introduced macrophytes

Adaptation Strategies for Wisconsin Lakes Facing Climate Change

Madeline Magee, Catherine Hein, and Tim Asplund
Wisconsin Department of Natural Resources, Madison, Wisconsin

Wisconsin's 15,000 inland lakes are a vital economic and cultural natural resource statewide but are threatened greatly by climate change. Recent harmful algal blooms, flooding, and fish kills can all be attributed to a warmer, wetter climate. To evaluate and compile adaptation strategies, the Wisconsin Initiative on Climate Change Impacts gathered researchers and managers with expertise on Wisconsin's inland lakes. We identified climate change impacts and possible adaptations strategies for four thematic areas relevant to inland lakes: water levels, water quality, aquatic invasive species, and fisheries. While adaptation strategies for each theme differ, there is consensus around the need for a multifaceted approach that incorporates communication and outreach, policy and regulation changes, traditional resource conservation approaches, and novel engineering designs. This approach should focus on protecting high-quality lakes, building lake resilience, and retaining beneficial ecosystem services. Thoughtful, strategic interactions with stakeholders are key to implementing these strategies.

Edina's Flood Risk Reduction Strategy

Jessica Wilson[1], Ross Bintner[1], and Sarah Stratton[2]
[1]City of Edina, Edina, Minnesota; [2]Barr Engineering Company, Minneapolis, Minnesota

Urban flooding is increasingly demanding the attention of water resources managers. Over a ten-month period, a task force of staff and community members worked to come to a shared understanding of what flooding is, what is valuable, and what matters, where, and to whom. The effort to put flooding into focus has resulted in the creation of a framework for understanding factors that define flood risk; climate, exposure, and vulnerability. Our definition of flood risk is adapted from the 2012 IPCC special report, "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation." We explored the factors that are driving increasing flood risk. The primary and secondary drivers are climate change and aging infrastructure. Well-drained landscapes and imperviousness also matter, but are more historical drivers of flood risk. We defined the sectors of municipal work within which we work to connect on the promise to comprehensively reduce the risk of flooding throughout the community; infrastructure, regulation, outreach and engagement, and emergency services.

This work to develop a strategy for reducing flood risk has resulted in a shift from a problem-solving paradigm to one of risk management.

General Session 3L: Aeration and Oxygenation

November 19, 2020 | 11:00 – 12:00

*Evaluating Stratification-Preserving and Destratifying Approaches to Aeration of a Drinking-Water Supply Reservoir

Niamh Brockbank[1], Lee Bryant[1], and David Austin[2]
[1]University of Bath, Bath, United Kingdom; [2]Jacobs, Saint Paul, Minnesota

Different methods of reservoir aeration and oxygenation are used to improve water quality and ecosystem health as function of increased dissolved oxygen concentrations (DO) and/or mixing levels. Two of the primary approaches used focus on either 1) preserving stratification and increasing DO within the hypolimnion (*e.g.*, hypolimnetic aeration; HA) or 2) destratifying the reservoir via increased mixing throughout the water column (*e.g.*, destratifying aeration; DA). A comparative understanding of the mechanisms involved with HA and DA systems is difficult due to the complex biogeochemical and physical controls on DO dynamics in different reservoirs. This novel study addresses this issue by evaluating the influence of both HA and DA on oxygen dynamics in a single reservoir, CW Bill Young in central Florida, during March – July 2016. An HA partial air-lift system had been in operation for several years leading up to this study, during which it was then turned off and replaced with a DA bubble-plume diffuser system in mid-May 2016. Using EXO multi-parameter vertical profile data, changes in mixing, DO and estimated hypolimnetic (or equivalent during DA) oxygen demand are characterised. Results show that the shift to DA caused increased, but variable, DO in the bulk water column; similar trends, however, were also observed in blue-green algae concentrations. Significantly increased and homogenous temperatures were observed throughout the water column in response to DA. Simultaneously, DO dropped in the benthic region. This study provides a valuable assessment of the positive and negative influences of both aeration strategies on reservoir water quality.

Lake Hodges, California Hypolimnetic Oxygenation Using a Speece Cone

David Clidence
ECO Oxygen Technologies, LLC, Indianapolis, Indiana

Hodges Reservoir was created with the building of Hodges Dam on San Dieguito Creek in 1918. Operated and maintained by the city's Public Utilities Department, the reservoir serves the San Dieguito Water District and Santa Fe Irrigation District as well as the city of San Diego. Lake Hodges takes in runoff from all over San Diego County and, as such, the water contains lots of impurities. These are cleaned up in filtration plants before going out to the public.

The purpose of the Hodges Reservoir Oxygenation System Project is to reduce and control excessive algal productivity in the reservoir with the intent to improve water quality and restore the drinking water supply allowing greater water supply interconnectivity and reliability. The Project involved the construction of a Hypolimnetic Oxygenation System (HOS) Speece Cone. The Speece Cone will add dissolved pure oxygen into the deep portion of the reservoir to make up for that lost by bacterial decay of algae, alleviating water quality problems, controlling algal blooms, internal nutrient cycling and improving fish habitat. The presentation will outline construction, installation and startup of the HOS system.

The author(s) of this abstract has/have a financial interest in: i) ECO Oxygen Technologies, LLC ii) Speece Cone, iii) Speece Cone Hypolimnetic Oxygenation System and iv) ECO2) as described.

Nanobubbles as a Chemical-Free Method to Reduce Algae Causing Taste and Odor Issues in a Drinking Water Reservoir

Christian Ference
Moleaer, Torrance, California

Nanobubbles have shown distinguished performance in challenging aspects of waterbody management due to their extremely high oxygen transfer efficiency (SOTE > 85%), neutral buoyancy, and mild chemical-free oxidation. A nanobubble generator was installed in April 2020 on a 1.7 surface acre, 23 acre-ft drinking water reservoir in Central California to increase dissolved oxygen concentrations in the hypolimnion and at the sediment water interface. Historically, oxygen levels averaged less than 2 ppm below 6 ft in depth contributing to internal nutrient loading, routine algae blooms, and ultimately taste and odor issues. Real-time remote sensors were deployed 1 ft above the sediment layer to monitor the water quality before and after the nanobubble generator installation.

The shore mounted nanobubble generator recirculated 150 GPM of water pulled from 10 ft in depth in the reservoir and returned at below 15 ft. The nanobubbles were generated with a 40% oxygen gas flow of 12 CFH at 100 PSI. Oxygen levels, temperature, ORP, turbidity, and other water quality parameters were measured at 15 min increments at two points in the reservoir. Data from the first 30 days of the 90-day nanobubble evaluation indicate oxygen levels increasing from 0 ppm to above 3 ppm and ORP increasing from as low as -450 mV to above +550 mV. The increased oxygen and ORP levels indicate a shift from anoxic to oxic conditions at the sediment layer that can support reduced internal nutrient loading, algae growth, and taste and odor issues.

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

Economic Analysis and Life Cycle Assessment of Hypolimnetic Oxygenation of a California Reservoir

Bryan Fuhrmann[1], Marie-Odile Fortier[2], Marc Beutel[2], Susan Teefy[3], Alex Horne[4], and Mark Mobley[5]
[1]SePRO Corporation, Sacramento, California; [2]University of California, Merced, Merced, California; [3]East Bay Municipal Utility District (EBMUD), Oakland, California; [4]University of California, Berkeley, Berkeley, California; [5]Mobley Engineering, Norris, Tennessee

A hypolimnetic oxygenation system (HOS) is a novel approach used to inject pure oxygen gas into the bottom water of eutrophic lakes and reservoirs to improve water quality by suppressing release of contaminants from the sediment, reducing associated summer algal blooms and improving source water treatability. HOS require significant capital investment for the initial construction and ongoing operating costs to purchase oxygen and perform system maintenance. However, costs can be offset and exceeded by the savings incurred in water treatment operations due to enhanced treatability of the source water. There is currently a lack of information regarding the impact of HOS implementation in eutrophic drinking water reservoirs on the financial benefit and carbon footprint of the associated water treatment operations. This study performed an economic analysis and a life cycle assessment (LCA) of a HOS installed in a California drinking water reservoir in 2001. Both analyses determined that a reduction in ozone use in the disinfection treatment process to remove taste and odor compounds resulted in the largest benefit overall. The economic analysis revealed that construction costs resulted in a larger net present value reduction than the cost of oxygen used over the HOS lifetime. The LCA revealed that oxygen use contributed the majority of HOS associated greenhouse gas (GHG) emissions and the emissions related to HOS construction were negligible. The results suggest that the implementation of HOS in this case study will be moderately profitable and lead to reduced GHG emissions over the assumed 60-year life of the system.

*Line Diffuser Hypolimnetic Oxygenation: A Pyrrhic Victory for DO?

Mark Seelos and Marc Beutel
University of California Merced, Merced, California

Line diffuser hypolimnetic oxygenation systems (HOSs) are commonly installed in lakes and reservoirs to increase dissolved oxygen (DO) in the profundal water column and sediment-water interface, which should decrease internal nutrient loading and the release of reduced metals, hydrogen sulfide, and methylmercury from profundal sediments. Though HOSs are operated to maintain thermal stratification, water column turbulence induced by the rising bubble plume can may enhance mixing of profundal waters into surface waters. We compared water quality data collected before (2005–2015) and during (2015–2020) operation of HOSs in four California reservoirs. HOS increased profundal DO to saturation in three of four reservoirs. Bottom temperatures increased between 2.5 °C and 5.5 °C on average during operation. Redox potential decreased in surface waters during HOS operation, suggesting transport of profundal waters into the photic zone. This is supported by increased temperature, total phosphorus, and sulfate (from oxidation of profundal sulfide) in surface waters. Chlorophyll *a* and phycocyanin concentrations increased notably in surface waters during HOS operation, suggesting that temperature and nutrient increases stimulated primary productivity. Furthermore, line diffuser HOS mobilized profundal sediments, increasing turbidity in profundal waters and reservoir outflow. Though bottom water DO concentrations increased, mixing effects appear to have outweighed the benefits of an oxic hypolimnion in lowering levels of internal nutrient loading.

General Session 3M: Fish Management

November 19, 2020 | 11:00 – 12:00

Assessment of Minnesota Lakes Using Fish-Based Index of Biotic Integrity Tools

Jacquelyn Bacigalupi and Derek Bahr
Minnesota Department of Natural Resources, Brainerd, Minnesota

Minnesota Department of Natural Resources biologists developed four fish-based Index of Biotic Integrity (FIBI) tools for assessing the health of Minnesota lakes of varying size and condition. The FIBIs are used to identify biologically impaired and exceptional lakes, and to complement pollutant-based water quality sampling efforts on lakes. Approximately 500 lakes in 28 watersheds have been assessed using FIBI data. In addition, FIBI survey data has been collected on hundreds of additional lakes for upcoming assessments. Investigations are completed to identify probable environmental stressors impacting impaired lakes, such as watershed disturbance, shoreline alterations, or barriers to connectivity. Most FIBI impairments are on lakes with watershed disturbance occurring in more than half of the upstream catchment and lakes with high levels of total phosphorus. Meanwhile, most lakes that contain exceptional fish communities are located in predominantly forested watersheds with much lower total phosphorus.

Fisheries Management for Improved Water Quality in Eagan, Minnesota

Jessie Koehle[1], Eric Macbeth[1], TJ DeBates[2], Jim Levitt[2], and Tim Ohmann[2]
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The species, numbers, and size of fish can dramatically affect lake ecology, nutrient levels, and water clarity. In a city with over 30 small and shallow eutrophic lakes, efforts to protect and improve surface water quality must consider fisheries population structures as well as water chemistry and watershed inputs. Eagan's fisheries management partnership between the City and the Minnesota Department of Natural Resources is a maturing part of Eagan's 30-year water quality management program. City staff now conducts annual fish population surveys, fish stocking, winter aeration, fishing classes, public angling surveys, and shoreline access improvements. Overall, fishing opportunities are a priority for City residents, and lake managers aim to maintain balanced fish trophic and size structures to better support water quality.

Top Down Control of a Planktivorous Fish Population to Improve Water Clarity

Alejandro Reyes[1], Hillary Kenyon[1], Mark Cornwell[2], and George Knoecklein[1]
[1]Northeast Aquatic Research LLC, Mansfield Center, Connecticut; [2]SUNY Cobleskill, Cobleskill, New York

Lake Oscawana is a 156-hectare lake located in southeastern New York (max depth 11 meters). Historically, excessive nutrients from internal and external sources have reduced clarity and impeded recreational use. One of the techniques chosen to improve clarity in the late 1980s was the stocking of walleye (*Sander vitreus*) to reduce the landlocked alewife (*Alosa pseudoharengus*) population which would result in a trophic cascade, ultimately improving water clarity. From 1989 to 2014, fingerling walleye were stocked to control alewife, but there was little to no monitoring to gauge success. In 2019, a fisheries survey was conducted to assess the current status of walleye and alewife in the lake. The fish data was compared to past zooplankton, algae, and phytoplankton data to evaluate the success of the previous stockings. Despite years of walleye stockings, alewife are still present and presumed to be highly abundant, large cladocerans are not a large part of the zooplankton community and water clarity has not measurably improved. We present data collected over a 20-year monitoring program and discuss mechanisms of top-down control specific to walleye and alewife in the northeast.

Potential of Long-Term Fish Removal in Eutrophic Lakes

Ilkka Sammalkorpi[1], Jouko Sarvala[2], Anne-Mari Ventelä[3], Jukka Ruuhijärvi[4], Mikko Olin[4], Jaana Hietala[5], and Arto Hautala[6]
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Eutrophic lakes are often characterized by a high cyprinid biomass. Effective fishing represents a potential sink to remove phosphorus from the lake ecosystem. Cost effective fish removal methods have been developed in biomanipulation of Finnish lakes. We estimated the role of the phosphorus pool in fish biomass removed in long management of eight lakes (area 145–15500 ha, retention time 0.2–4.9 years, external phosphorus load < 0.1–0.6 g P m^{-2} a^{-1}, fish removal 0–240 kg ha^{-1} a^{-1} and duration of fish removal from five to 20+ years). The phosphorus pool removed in fish biomass (FP_{out}) was compared with parameters of nutrient balances. It was up to 25 % of the mean annual external total phosphorus (TP) loading, it could exceed 50 % of the mean TP concentration of the lake water, mean sedimentation of TP and TP of outflow. The relative importance of FP_{out} depended on the efficiency of fishing and retention time. By shorter retention time and high external loading, even high catches in kg ha^{-1} a^{-1} were lower compared with the external load, but their percentage of retention and annual outflow of phosphorus increased. Our results suggest that biomanipulation can, in addition to the positive short-term impacts, also support long term nutrient removal in the river basin scale. It does not compensate the necessary long-term measures reducing diffuse external loading which are tackled (*e.g.,* in agricultural policy).

General Session 3O: Monitoring – Fluorescence

November 19, 2020 | 11:00 – 12:00

Lake Sediments Help Recognize the Historical Presence of a Nuisance Alga on Vancouver Island, British Columbia

Alexandra Di Lonardo and Joshua Kurek
Mount Allison University, Sackville, New Brunswick, Canada

Didymosphenia geminata (Didymo) is a freshwater benthic alga which occurs in nutrient poor streams and rivers across Canada. Didymo blooms impact the riverbed environment and invert communities with thick mats of biomass, which have increased concerns of its impacts to fish, especially juvenile salmon. Because Didymo prefers low nutrient conditions, bloom-prone areas often occur in remote environments which lack long-term monitoring data, leading to a gap in knowledge of baseline environmental conditions prior to blooms. Consequently, the historical presence of didymo and environmental drivers of blooms are poorly understood. Our study addresses the following questions: Are the reported algal blooms in the upstream watershed a novel phenomenon? And what are the drivers associated with blooms? To answers these, our study uses lake sediment cores as natural archives of past environmental conditions. The study site, Cameron Lake, British Columbia, has reported Didymo blooms in its watershed since 1991. The research will use X-Ray Fluorescence (XRF) to identify watershed changes as well as observations of Didymo to identify diatom abundance and presence through time. Preliminary results recognized that Didymo was historically present in low abundances with proliferation in abundances occurring only recently. This result indicates that blooms are likely a novel phenomenon and suggests the watershed is undergoing a period of change to conditions favoring blooms.

Is There F.I.Z. in Your Fluorometer Data?

Vincent Moriarty[1], Mark Lucius[2], Ken Johnston[2], Jonathan Borrelli[2], Lawrence Eichler[2], Brian Mattes[2], Alex Pezzuoli[2], Campbell Watson[1], and Rick Relyea[2]
[1]IBM Research, Yorktown Heights, New York; [2]Rensselaer Polytechnic Institute, Troy, New York

Traditional fluorescence-based sensors can be used for *in situ* measurements of photosynthetic pigments associated with phytoplankton. These sensors are often used as part of water quality monitoring programs, and for the detection of harmful algal blooms (HABs). To measure chlorophyll *a* fluorescence (Fchl), fluorometers use an excitation wavelength that is within the visible spectrum of most zooplankton, and as a result has the potential to cause a phototactic response. The transparent bodies of herbivorous zooplankton may allow viable chlorophyll *a* within an individual's digestive tract to fluoresce in response to sensor excitation light, resulting in measurement bias. To test for this bias, a fully factorial (± zooplankton and ± light) experiment was conducted in a large, oligotrophic lake. Excitation light from fluorometers triggered a positive phototactic response during nighttime hours, resulting in swarms of zooplankton congregating beneath the sensor. The maximum hourly mean Fchl from nighttime/open treatments was higher and more variable than nighttime/zooplankton exclusion treatments. In open treatments, sustained periods of increased Fchl exceeded 31× the values of exclusion treatments. An analysis of multiple long-term sensor networks found similar irregularities in fluorometer data across a variety of lake types. Collectively, these results suggest that swarms of phototactic zooplankton can cause substantial bias in Fchl measurements at night. To correct for this bias, post-processing methods using time-series decomposition were demonstrated to remove the majority of Fchl bias.

Poster Sessions

Poster Session A

November 17, 2020 | 17:00 – 18:00

*Influence of Reservoir Volume Alterations Under Climate Change and Impacts on the Trophic State of the River-Lake Transition Zone

Carolina C. Barbosa, Fellipe H. M. Moutinho, and Maria do Carmo Calijuri
Hydraulics and Sanitation Department, São Carlos School of Engineering, University of São Paulo, São Carlos, São Paulo, Brazil

The present study compared the longitudinal and seasonal variation of chlorophyll *a* (Chl-*a*) and total phosphorus (TP) concentrations of Itupararanga reservoir (SP/Brazil) to a trophic state index (TSI) for (sub)tropical reservoirs in three sampling stations (in the riverine, transitional and lacustrine zones). Data compilation (January 2009 to January 2018) of hydrologic (Votorantim Energy Company) and water quality monitoring stations (Environmental Company of São Paulo State) was complemented with bimonthly field survey (October 2018 to July 2019). Results indicated eutrophic level in the riverine zone and a tendency to mesotrophic state along the longitudinal gradient. In addition, the trophic state remained unchanged regarding to the reservoir level alterations in the riverine and lacustrine zones. However, the transition zone indicates that the trophic state changes year by year, mainly driven by TP concentrations. Furthermore, between 2014 and 2015, during and after the drought faced to Southeast of Brazil, the average daily volume of Itupararanga reservoir dropped ~29%. The transition zone became eutrophic ($TSI_{2014} = 56.4$; $TSI_{2015} = 57.6$) and the main drive was the increase of Chl-*a* concentrations between November 2014 and July 2015, during and after the drought period. A new reservoir level decrease was observed from 2018 to 2019 and the Chl-*a* concentrations were above the daily average (26 µg l^{-1}). Meanwhile, TP levels were low (15 µg l^{-1}), maintaining the mesotrophic state of the transitional zone ($TSI_{2014} = 55.4$). Alterations of water levels due to changes in the rainfall regime may increase the primary productivity, especially in the transitional zone, requiring additional investigation.

*Effects of Fish Communities on Freshwater Amphipod Stocking Success in Minnesota, USA

Michael Bieganek[1], Jake Carleen[2], Danelle Larson[3], Emily Schilling[1], Megan J. Fitzpatrick[4], and Michael J. Anteau[5]
[1]Augsburg University, Minneapolis, Minnesota; [2]Bemidji State University, Minnesota; [3]US Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin; [4]Minnesota Department of Natural Resources, Wetland Wildlife Population and Research Group, Bemidji, Minnesota; [5]US Geological Survey Northern Prairie Wildlife Research Center, Jamestown, North Dakota

Amphipods are an important ecosystem component in North America's prairie pothole wetlands, but their populations have declined. We are using a Before-After/Control-Impact study design to test the efficacy of stocking amphipods to establish abundant *Gammarus lacustris* populations. We stocked *Gammarus* into 22 wetlands during winters 2017–2020. Each stocked wetland was paired with a nearby control wetland. We conducted pre- and post-stocking surveys during fall (September – October). So far, *Gammarus* have not been found in post-stocking surveys in any stocked wetlands. Increasing occurrence of fish in prairie pothole wetlands has been linked to declining amphipod populations. To explore whether fish may be preventing stocking success, we surveyed fish communities in stocked (n = 5) and control (n = 4) wetlands, as well as wetlands with naturally-abundant *Gammarus* densities (> 300 m^{-3}; hereafter "natural" wetlands; n = 6). Of the four commonly occurring fish species, brook stickleback and fathead minnows were found in both stocked and natural wetlands, whereas black bullheads and central mudminnows were found only in stocked wetlands. Average fish counts by species, average biomass of feeding guilds (benthivore, planktivore, piscivore), and average total fish biomass did not differ significantly among stocked, natural, and reference wetlands in preliminary ANOVA tests. Next year, fish will be surveyed at an additional 15 stocked/control wetland pairs. Our research should help understand the importance of existing fish communities on success of *Gammarus* stocking.

 # Presentation includes citizen science content

*Modelling the Failure of Bubble Plumes to Maintain a Well-Mixed Water Column in a British Reservoir During a Heatwave

David Birt[1], Jun Zang[1], Lee Bryant[1], and Danielle Wain[2]
[1]University of Bath, Bath, United Kingdom; [2]7 Lakes Alliance, Belgrade Lakes, Maine & Colby College, Waterville, Maine

Artificial destratification is a globally employed technique to maintain water quality throughout the summer by water column circulation and aeration. During June 2017, a heatwave struck Europe in Blagdon Lake, a drinking water reservoir near Bristol, UK, the water column stratified during the warm weather, despite operation of seven bubble plumes proximal to the intake tower, highlighting the reservoir's vulnerability to extreme weather events. To further explore this vulnerability, this period was modelled in both a 3D coupled hydrodynamic-biogeochemical model, AEM3D and a 1D lake physics-ecology model, GLM. These models will also be considered in future climates so climate change can be considered. The models were informed from in-situ two temperature chains and profiling for water quality parameters. Forcing data was gathered from Centre for Environmental Data Analysis. Future data was taken from the daily RCP 8.5 climate protections data from the UK Climate Projections then temporally downscaled. Calibration involved running multiple iterations of the models with modified parameters until a run with a low root mean squared error (RMSE) corresponding with a good fit was found. Both models capture stratification onset well experience over mixing. Current average RMSE is around 0.6 °C for both models. Hydrodynamic calibration was prioritised over biogeochemistry which is currently in progress. Initial results show, that despite indirect forcing data, the model has been able to simulate much of the reservoir's physics including factors linked to water quality. This study highlights the ineffectiveness of poorly designed destratification systems and how it hampers reservoirs resilience.

*Using Satellite Imagery to Identify Relationships Between Water Color and Water Quality Parameters for Minnesota Lakes

Martha Burket[1], Leif Olmanson[2], and Benjamin Page[3]
[1]Department of Civil, Environmental, and Geo- Engineering, University of Minnesota, Minneapolis, Minnesota; [2]Forest Resources, University of Minnesota, St. Paul, Minnesota; [3]Water Resources Center, University of Minnesota, St. Paul, Minnesota

Satellite data can be used to measure the hue angle and dominant wavelength of surface waters. These data can then be used to quantify the color of a water body, which is useful information because water color can be related to perception of suitability and water quality. The goal of this study is to establish a relationship between water color (defined using chromaticity coordinates) and water quality variables for Minnesota (MN) lakes. Chromaticity coordinates were calculated using remote sensing reflectances (Rrs) over lake pixels from multi-temporal composites of cloud-free Sentinel-2 imagery. The dominant wavelength was calculated and used to classify 10,000+ lakes in MN by color. Lake color varied across MN, with a concentration of blue lakes in northeast MN, yellow and green lakes in central MN, and yellow lakes in southern MN. The calculated dominant wavelength was also used as an input to a k-means clustering analysis that explored relationships between water color and in-situ water quality data for 262 lakes in MN.

*Do Wetland Fish Influence the Presence and Abundance of Amphipods in Western Minnesota?

Jake Carleen[1], Danelle Larson[2], Michael Anteau[3], Carl Isaacson[1], Andrew Hafs[1], Megan Fitzpatrick[4], and Breanna Keith[1]
[1]Bemidji State University, Bemidji, Minnesota; [2]US Geological Survey, LaCrosse, Wisconsin; [3]US Geological Survey, Jamestown, North Dakota; [4]Minnesota Department of Natural Resources, Bemidji, Minnesota

Amphipods (primarily *Gammarus lacustris* and *Hyalella azteca*) are crustaceans found throughout North America's Prairie Pothole Region. Amphipods are an integral part of wetland ecosystems and heavily utilized for food by fish and wildlife. In the last thirty years, amphipod abundance has apparently declined, coinciding with the declining population of Lesser Scaup (*Aythya affinis*). Linked with amphipod declines are increases in fish in previously fishless wetlands and shallow lakes. Fish have detrimental effects on amphipod abundance both directly through predation and indirectly through habitat degradation. In this study, we assessed impacts of fish communities on amphipod occurrence and abundance in western Minnesota. Previous studies using random basin selection were limited by yielding few replicates of basins with high amphipod densities. We avoided this issue by selecting roughly half of our 49 study basins from basins known to have robust amphipod populations. We found amphipods in 86% of surveyed basins and encountered wide gradients of fish abundances (0 to 2586 fish per basin). Increased fish biomass reduced occurrence probability of *G. lacustris* for basins ($\chi 2(48) = 4.70$, $p = 0.03$). However, preliminary linear regression models assessing fish abundance or biomass as an explanatory variable for *G. lacustris* or *H. azteca* abundance were not significant ($p > 0.05$). Redundancy analyses revealed significant, negative associations of the amphipod community to benthivores but not with planktivores or piscivores ($F(1,45) = 6.46$, $p < 0.01$). We will survey an additional 30 basins during 2020 to further understand how fish influence amphipod presence, abundance, and distribution in western Minnesota.

*Bridging Water Quality Data and Citizen Science Using Fuzzy Logic and Narrative

Kat Kavanagh
Water Rangers, Ottawa, Ontario, Canada

This talk presents research on storytelling in water quality monitoring through fuzzy logic as a more effective way to motivate members of the public than traditional scientific communication. In it, a model to predict water quality to citizen scientists is presented and woven into a narrative. The model uses a fuzzy logic method that first calculates background information based on rockbed, soil, flow and seasonal variation, and then predicts results based on one simple water quality input from citizens (conductivity), along with levels of urbanization and any existing health scores, to determine a new model for water quality health. By combining predictions on background levels with conductivity, the model creates a meaningful way for citizens to test for and understand water health in real-time to answer the fundamental question: are my results good or bad?

*Western Minnesota's Shallow Lake and Wetland Conditions and Associated Implications for Freshwater Amphipods

Breanna R. Keith[1], Danelle Larson[2], Carl Isaacson[1], Michael Anteau[3], Megan Fitzpatrick[4], and Jake Carleen[1]
[1]Bemidji State University, Bemidji, Minnesota; [2]US Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin; [3]US Geological Survey, Northern Prairie Wildlife Research Center, Jamestown, North Dakota; [4]Minnesota Department of Natural Resources, Wetland Wildlife Population and Research Group, Bemidji, Minnesota

Amphipods (*Gammarus lacustris* and *Hyalella azteca*) are important components of North America's prairie lake and wetland food webs. Declining amphipod abundance at spring stopover habitat for birds prompts a need to understand characteristics of extant amphipod-rich aquatic systems. We surveyed 49 shallow lakes and wetlands throughout western Minnesota to examine how water chemistry and adjacent landscape characteristics influence amphipod and aquatic plant abundance. Due to the scarcity of amphipod-rich wetlands, half of our basins were randomly selected and the rest were selected for known amphipod abundance; altogether, densities ranged from 0 to 7,000 amphipods per m^3. We found that 70 percent of shallow lakes and wetlands contained total phosphorus exceeding 50 μg/L, but the majority still existed in a clear-water state with abundant submerged aquatic vegetation (SAV). Regression models revealed few distinct relationships between water chemistry and amphipods, but SAV abundance was negatively correlated with water depth and turbidity. Landscape-level analyses indicated that both *H. azteca* and *G. lacustris* can persist and occasionally thrive across a gradient of agricultural intensity. Even so, *H. azteca* density, SAV abundance, and SAV species richness was positively correlated with riparian buffer, supporting the consideration of how upland management strategies impact aquatic systems in modified landscapes. We'll continue studying direct and indirect effects of abiotic conditions on amphipods and are investigating insecticide contamination to better quantify impacts of anthropogenic stressors.

*Socio-Ecological Synergies for a Sustainable Onondaga Lake: Reckoning With the Complexities of Restoration

Skyler Maassen, Myra Armstead, Robyn Smyth, and Monique Segarra
Bard College, Annandale-on-Hudson, New York

After decades of industrialization in its vicinity, Onondaga Lake in central New York State was once considered "the most polluted lake in America." Recently, however, the system was declared recovered and ready for human use. Honeywell International Inc. – supervised by the New York State Department of Environmental Conservation and the United States Environmental Protection Agency – and their partners completed considerable clean-up in the last two decades. Efforts included dredging, capping, and habitat enhancements. These efforts have led to renewed ecosystem services, but the endpoints of ecological restoration are unclear. Prompted by inconsistent theory and practice of restoration, this study investigates how opinions among and within stakeholder groups – Honeywell and Associates, non-governmental organizations, academic institutions, and governmental agencies – vary in the case of Onondaga Lake. Via analysis of qualitative and semi-quantitative data pulled from a series of interviews, this study examines the extent to which criteria of Onondaga Lake's restoration were met and recommends further management actions. Circumstances are complicated by Onondaga Lake's long history and this study found perceptions of ecological restoration were different according to personal and professional experiences with the lake, which rest upon diverse values and interests. Results show the complexity of restoration procedures, including the determination of restoration targets and goals, success metrics, methods to be employed, and how to assess progress. An adaptive management approach is endorsed for future restoration work.

*Determining Effects of Boat Use on Lake Shoreline Erosion in Maine

Melissa Macheras
Plymouth State University, Plymouth, New Hampshire

Multiple lakes in northern New Hampshire and western Maine have recently experienced issues with shoreline erosion and deep-water anoxia. As shoreline erosion increases, an influx of organic material is transported into the lake. As it settles to the bottom and begins decomposing, the water in the deeper layers of the lake can become anoxic. Using sediment cores and sedimentological data from two lakes in Lovell, Maine, Kezar Lake and Horseshoe Pond, this project aims to determine the cause of this recent shoreline erosion and deep-water anoxia in Kezar Lake. Both Kezar Lake and Horseshoe Pond exist within the same watershed and thus any increases in erosion due to regional climate change should be seen in both lakes. Kezar Lake is a popular tourist destination and allows many types of recreational boating activities whereas Horseshoe Pond is a smaller pond that is less popular and has more restrictions regarding boat use. Over the last 30 years there has been a large increase in recreational boating on the lakes in this region. We hypothesize that this increase in shoreline erosion in Kezar Lake may be due to an increase in wave-directed energy from recreational boating, resulting in increased turbidity, organic debris in shallow regions and, ultimately, enlarged anoxic zones.

*Applying the Varimax Rotated Spectral Decomposition Method and Satellite Observations to Analysis the Water Quality of Lake Ontario

FM Arifur Rahman, Dulcinea Avouris, and Joseph D. Ortiz
Department of Geology, Kent State University, Kent, Ohio

Since 1960 excessive algal blooms have been a major threat to the water quality of the Laurentian Great Lakes. Lake Ontario, shared by the USA and Canada, has experienced problems in this regard. An excessive amount of N and P are of great concern for Lake Ontario. It is challenging to identify optical constituents using traditional remote sensing, given its optically complex water. The Kent State University Varimax Rotated Principal Component Analysis (KSU VPCA) spectral decomposition method is a remarkably effective means to partition the signatures of optically active water constituents from visible reflectance spectra using lab, field, or satellite instruments. KSU VPCA method has been applied to Sentinel-3A/B OLCI Level 2 data to develop a seasonal time series from 2017 to 2019. From the cloud-free daily images collected during the summer season of 2017 preliminarily analysis indicates spectral responses related to Chlorophyll *a*, allophycocyanin, and phycocyanin and with a variety of other accessory pigments and minerals that account for smaller fractions of image variance. Associated lake surface water temperature map evaluated along with the component signals suggest that different water surface masses are combined with different optical signatures that exemplify seasonal changes in environmental control. Combining environmental remote sensing methods with field observations provides more reliable information to address drinking water, health, and recreational problem that are relevant to water managers and stakeholders.

*Understanding the Impact of Local Land-Use on Nearshore Water Quality and Primary Productivity in a Large, Shallow Lake

Erin Smith and Andrea Kirkwood
Ontario Tech University, Oshawa, Ontario, Canada

Water quality in a lake ecosystem is directly tied to land-use type and intensity in the lake's watershed. Although it is well known that land-use in a watershed influences water quality, the scale of influence can vary across lakes. At the local scale, the impact of various kinds of shoreline development on lake health is less well understood. Lake Scugog is a large, shallow lake in Southern Ontario, just north of the heavily populated Greater Toronto Area (GTA). Scugog's watershed is dominated by agricultural land-use, however the Town of Port Perry, and many exurban communities along the shoreline are continuing to expand. In order to determine the impact of shoreline development around Lake Scugog, we measured water quality, environmental conditions, and primary production in the nearshore zone over two years. Primary production was measured in three ways: phytoplankton biomass, periphyton biomass, and aquatic plant abundance. We found that water quality, specifically total phosphorus and chloride, in the nearshore zone was significantly influenced by developed land-use within a 1-km radius, compared to both agricultural land-use and natural land-cover. In addition, sites located in areas with higher development had consistently high levels of all three primary producers. There was no evidence of a shift from macrophyte- to algae-dominated primary production, despite the high nutrient levels in all areas of the lake. It is expected that if shoreline development continues, the blue-green algae blooms and over-abundance of submerged macrophytes will be increasingly common in Lake Scugog.

*Accumulation and Discharge of Road Salt From a Constructed Wetland

Robyn Smyth and Mikaela Martiros
Bard College, Annandale-On-Hudson, New York

Constructed wetlands are increasingly promoted and used to treat urban stormwater runoff. By replicating the elements and functions of natural wetlands, constructed wetlands are designed to collect, slow down, and improve the quality of urban stormwater while providing co-benefits like carbon sequestration and habitat not provided by traditional stormwater infrastructure. In this study, we evaluate the effectiveness of a small (< 0.1 ha) stormwater treatment wetland built in 2014 on Bard College's campus in Annandale-on-Hudson, New York. We find that turbidity levels are decreased from inlet to outlet but conductivity often increases. We show that the wetland has, over nearly 5 years of operation, accumulated a considerable amount of road salt such that median conductivity levels throughout the system exceed 1000 μS/cm year-round. We found high conductivities (400–800 μS/cm) exiting the system in the fall of 2018, prior to the winter salting season. Chloride concentrations measured during spring amphibian breeding season exceeded 200 mg/L, levels that may have negative impacts on some species. Monitoring data has also been used to develop a mass balance model for assessing the internal dynamics of the system as it is affected by road salt inputs. Freshwater salinization is an issue of increasing concern in northern latitudes where road salt is routinely and liberally applied as part of winter road maintenance. Our results suggest that constructed wetlands will require active maintenance (pumping) if they are to be used as a road salt mitigation strategy.

*Can an Interactive Data Visualization Tool Change Waterfront Property Owners' Behavior?

Nicole K. Ward[1], Michael G. Sorice[2], Kathleen C. Weathers[3], and Cayelan C. Carey[1]
[1]Department of Biological Sciences, Virginia Tech, Blacksburg, Virginia; [2]Department of Forest Resources and Environmental Conservation, Virginia Tech, Blacksburg, Virginia; [3]Cary Institute of Ecosystem Studies, Millbrook, New York

One aspect of science communication focuses on translating scientific knowledge to the public to change their behavior. It remains unknown the extent to which emerging technologies in science communication, such as interactive data visualizations, can promote environmentally sound management via behavioral intention to improve environmental management practices. In this study, we co-produced an interactive visualization tool based on lake and watershed data to ask the question: Does use of an interactive data visualization tool influence lakefront owners' behavioral intentions regarding best management land practices on their property? We addressed this question in Lake Sunapee, New Hampshire (USA). In the first phase of the study, we developed an online visualization tool (Shiny app) using formalized feedback from > 30 lake managers and researchers. In the second phase of the study, we deployed a survey assessment of the effectiveness of the visualization tool in altering intended behavior of > 50 landowners in the Lake Sunapee watershed. Our co-produced app included visualizations of lake water quality in response to choices homeowners "made" about fertilizer application and shoreline buffers. Our interdisciplinary work highlights the importance of co-production for interactive science communication tools, including a combination of approaches from scoping meetings with key stakeholders and formalized feedback from a wide range of potential users. This study will provide important evaluation of the role of new interactive technology tools for promoting environmentally sound management decisions.

*Decision-Making Under Uncertainty: Optimizing Forecast Visualizations for Drinking Water Managers

Whitney Woelmer and Cayelan Carey
Virginia Tech, Blacksburg, Virginia

There is an increasing need for adaptive and preemptive management of water resources in response to degradation of freshwater ecosystems. As freshwaters experience changing climate and land use conditions, their ecosystem services (*e.g.*, drinking water, recreation, aesthetics) are also becoming more variable. Consequently, management decisions based on historical conditions may become less useful for freshwaters in the future. Near-term water quality forecasts are one tool that can provide water resource managers with a quantitative estimate of a future ecosystem service. However, the inherent uncertainty embedded in a forecast estimate of future conditions can hamper the integration of forecasts into decision-making workflows. In particular, the way that forecast uncertainty is visualized can influence the way end-users interpret the forecast and make decisions. In this study, we aim to examine how different representations of forecast uncertainty affect decision making in drinking water managers. We have developed five representations of uncertainty in a severe algal bloom forecast. Drinking water managers will receive one of five visualizations, after which they will be asked to make a hypothetical decision about drinking water management, given the predicted scenario. Preliminary results indicate that there are marked preferences for certain visualizations: forecasts that summarize uncertainty, rather than visualizing the full uncertainty spread, are most highly preferred. Our overarching objective is to improve the translation of ecological forecasts for effective management of drinking water sources.

Poster Session B

November 18, 2020 | 17:00 – 18:00

Turning Up the Heat: Effects of Wildfire and Climate Warming on Water Quality of a Hypereutrophic California Lake

Angela De Palma-Dow[1], Ian M. McCullough[2], and Jennifer Brentrup[3]
[1]Lake County Water Resources Department, Lakeport, California; [2]Michigan State University, East Lansing, Michigan; [3]University of Vermont, Burlington, Vermont

The Mendocino Complex was the largest wildfire in post-settlement California history, burning 459,123 acres from July to November 2018. The Complex burned 40% of the Clear Lake watershed, raising concerns about fire and fire response effects on water quality. Clear Lake is the largest natural lake entirely within California, is hypereutrophic and is primarily used for recreation, drinking water, tribal use, and supports a tourism-based local fishing economy. Long-term lake monitoring since the 1960s facilitates contextualization of post-fire water quality with respect to long-term trends. Results indicated that historic wildfire watershed burn area was not associated with total phosphorous (TP) in Clear Lake although TP has increased 3–5 µg/L/yr since the late 1960s across three surface sample stations. When comparing pre and post-fire surface Chl-*a* (and TSS) post-fire concentrations were within historical ranges of variability. Long-term TP was more strongly correlated with maximum air temperatures than precipitation or watershed wildfire area, suggesting a role of warming-induced sediment resuspension and dissolved oxygen depletion in long-term TP increases. Overall, our results suggest greater vulnerability of large, eutrophic or hypereutrophic lake water quality to long-term climate warming rather than episodic, large wildfires due to high pre-fire nutrient pools. Nonetheless, our study underscores the value of long-term water quality monitoring and the need to study fire effects across a wide range of lake, landscape and fire characteristics to promote more effective future water resource management.

Reflectance Spectroscopy and Algae Concentration in the Finger Lakes

Ileana Dumitriu[1], Peter J. Spacher[2], John Halfman[1,3], and Lisa Cleckner[3]
[1]Hobart and William Smith Colleges, Geneva, New York; [2]Rochester Institute of Technology, Rochester, New York; [3]Finger Lakes Institute, Hobart and William Smith Colleges, Geneva, New York

The transient nature of harmful algal blooms (HABs) in both space and time result in monitoring challenges. *In situ* testing to determine the presence of HABs is time consuming and expensive. The use of drones outfitted with spectrometers to detect HABs could prove to be a more cost effective and efficient practice. In the present study, reflectance spectra and water quality *in situ* parameters were measured at the same time and location during 2019 monthly water quality surveys of the eight eastern Finger Lakes. Spectra's peak heights were correlated to algae (chlorophyll *a*) concentrations measured in the laboratory.

Nanobubbles as a Chemical-Free Method to Reduce Algae Causing Taste and Odor Issues in a Drinking Water Reservoir

Christian Ference
Moleaer, Torrance, California

Nanobubbles have shown distinguished performance in challenging aspects of waterbody management due to their extremely high oxygen transfer efficiency (SOTE > 85%), neutral buoyancy, and mild chemical-free oxidation. A nanobubble generator was installed in April 2020 on a 1.7 surface acre, 23 acre-ft drinking water reservoir in Central California to increase dissolved oxygen concentrations in the hypolimnion and at the sediment water interface. Historically, oxygen levels averaged less than 2 ppm below 6 ft in depth contributing to internal nutrient loading, routine algae blooms, and ultimately taste and odor issues. Real-time remote sensors were deployed 1 ft above the sediment layer to monitor the water quality before and after the nanobubble generator installation.

The shore mounted nanobubble generator recirculated 150 GPM of water pulled from 10 ft in depth in the reservoir and returned at below 15 ft. The nanobubbles were generated with a 40% oxygen gas flow of 12 CFH at 100 PSI. Oxygen levels, temperature, ORP, turbidity, and other water quality parameters were measured at 15 min increments at two points in the reservoir. Data from the first 30 days of the 90-day nanobubble evaluation indicate oxygen levels increasing from 0 ppm to above 3 ppm and ORP increasing from as low as -450 mV to above +550 mV. The increased oxygen and ORP levels indicate a shift from anoxic to oxic conditions at the sediment layer that can support reduced internal nutrient loading, algae growth, and taste and odor issues.

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

#Using Citizen Science Data to Assess Eutrophication Trends in Lakes of New York

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The study of eutrophication in lakes of North America is becoming increasingly important as anthropogenic sources of nutrients fertilize freshwater bodies. Understanding the relative threat to lakes from eutrophication will allow managers, stakeholders, and scientists to make informed decisions about the allocation of resources for prevention, monitoring, and mitigation. In this study, we analyzed long-term data sets of twenty-seven lakes collected by members of New York's Citizens Statewide Lake Assessment Program (CSLAP) to examine how total nitrogen (TN), total phosphorus (TP), and chlorophyll *a* (chl-*a*) concentrations have changed over time. Using a combination of Mann-Kendall tests and t-tests, we found lake-to-lake variability in TN, TP, and chl-*a*, with some showing increases while others show decreases or no significant changes over ten years or more. We also found synchronicity across the state in years with high and low concentrations of chlorophyll and nutrients. We compared trends in CSLAP data to qualitative expert perceptions of lake eutrophication trends collected with a 2016 survey of lake scientists, managers, and stakeholders affiliated with NALMS and the Global Lake Ecological Observatory Network (GLEON) to assess the distribution of ecological threats to lakes. The results of this study emphasize the importance for citizen scientists to continue to monitor lakes in New York and beyond to track changes in nutrient concentrations and algal growth over space and time.

Columbia Basin Water Monitoring Collaborative and Open Source Data Platform: Developing a Collaborative Water Balance Model Approach to Expand the Water Monitoring Network in the Upper Canadian Columbia Basin

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Water resources are changing rapidly during a general and long-term decline in monitoring efforts. Pressing water resource issues at local and regional scales reflect a range of escalating pressures on resources and include climate impacts such as extreme precipitation, flooding, fire events and peak glacial melt. Site-specific reactive monitoring can never satisfy the myriad of data requirements for all local water issues. Variability in hydrologic response across the Columbia Basin is too great to be sufficiently understood based on current monitoring. Potential monitoring is effectively infinite but resources are limited. It is necessary to refocus in planning future monitoring to carefully allocate limited resources to meet multiple scientific objectives. Recommendations for a phased expansion of the water (and water-related) monitoring network of Canada's Upper Columbia Basin (UCB) include priorities for monitoring identified within a scientific framework that distinguishes hydrologic variability according to known variation in climate within the UCB. Within this broad framework of the UCB's 10 hydrologic regions, setting priorities is based on hydrologic and terrain characteristics, compelling scientific questions, and prevailing water resource issues. These considerations go beyond what is needed to serve the Columbia River Treaty and its renegotiation because the monitoring network must address and support a wider array of issues and activities. It takes into account the full range of variation of potential watershed response within the UCB while also emphasizing watersheds critical to biodiversity conservation, community sustainability, and ecosystem resilience in the face of climate disruption.

Flathead Basin Stormwater Project: A Case Study in Collaboration-Based Conservation

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As populations in the area continue to increase, Flathead Watershed in northwestern Montana is anticipated to experience threats to water quality in the future. In light of this, Flathead Basin Commission, a local watershed group, and the City of Kalispell, a local government body, partnered up to develop a multi-faceted project that addresses nonpoint source pollution from stormwater in the Watershed. Based on the watershed approach to water resource management, this project, known as the Flathead Basin Stormwater Project, relies on science-based, community-based, and education-based initiatives to better understand and mitigate stormwater pollution; and it has facilitated partnerships with scientific, governmental, and environmental advocacy groups across the Basin. The science-based initiative involves monitoring exercises, including stormwater sampling and dry-weather outfall inspections for illicit discharge detection, while the community-based initiative relies on citizen scientists and local governments to collect and share stormwater infrastructure data across the Basin. Both of these initiatives have achieved the Project's goal of developing a comprehensive map of stormwater infrastructure in the Basin and an outfall prioritization ranking scheme to inform future water quality monitoring efforts. The education-based initiative, which has become known as the Flathead Rain Garden Initiative, involves working directly with homeowners to inform them about the negative effects of nonpoint source pollution and the steps they can take to mitigate it through the construction of rain gardens. Relying heavily on partnerships with a large variety of stakeholders, the Flathead Basin Stormwater Project is a prime example of successful collaboration-based conservation.

Case Studies of Bottom-Sealed Filter Barriers to Reduce Nutrient Inflow Into Lakes and Ponds

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Lake preservation, restoration, and proper nutrient management are becoming an increasing concern as the prevalence of nuisance and harmful algal blooms (HABs) continues to rise across the world. While restoration and maintenance are important, the process often requires overlapping approaches: some long-term, others tedious, repeated annually, or expensive. Further, restoration efforts are sensitive and frequently overwhelmed by a nutrient influx during significant wet weather events or abnormally wet seasons. Prevention is a key aspect of lake management that is often overlooked and poorly understood. Nonpoint source pollution accounts for a significant portion of nutrient input into surface waters, and inlet streams can be a big culprit. Nutrient removal filter barriers (NRBs) are floating, anchored filter barrier curtains that have been deployed in recent years and been shown to reduce the input of nutrients through filtration and allowing flow to pass through the full curtain area. NRBs work in the preventative phase by reducing the input of nutrients and helping mitigate future problems. They can also be used in tandem with restoration efforts to allow a buffer during wet weather events. In this presentation we provide several case studies in the northeast region that showcase how NRBs can be effective at reducing nutrient inputs. In particular, we highlight an experimental three-barrier system study in Maine. Results of this study have indicated a reduction of total phosphorus averaging 55% per season. Our hope is to implement further understanding and continue to improve NRBs to highlight practical solutions to prevent nutrient inflow.

Influence of Water Lily Coverage on Select Water Quality Parameters in Lake Tibet, New York

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We investigated seasonal and spatial trends in temperature, dissolved oxygen, total phosphorus and ammonia-nitrogen in a shallow, water lily dominated lake in New York (Lake Tibet, Putnam County). Historical mechanical harvesting has had limited success while other management options are limited due to wetland regulations and the target plant being a native species (*Nymphaea odorata*). Despite white water lily being native, it is a highly aggressive plant and is the dominant species in Lake Tibet covering at times 70% of the lake surface area. To justify the management of this species, an understanding of the impacts of dense lily coverage on water quality is warranted. Stark differences were observed between areas with dense lily coverage and areas with sparse to no coverage. Temperature differences between the surface and the bottom were greater in lily beds than in open water, and dissolved oxygen was lower in lily beds at both the surface and the bottom. Total phosphorus and ammonia-nitrogen varied seasonally but did not differ between lily coverages. The data collected in this study provides justification for selective management of water lilies to increase dissolved oxygen conditions lake wide, which may in-turn aid ecological functioning.

EPA's See a Bloom, Give it Room – High School Video Challenge

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A harmful algal bloom (HAB) is an overgrowth of algae in a water body that can affect water quality and aquatic life. Some blooms can produce toxins that may also harm people, animals, and the local environment.

EPA created a challenge for high school students to make videos to teach people how to spot harmful algal blooms and how to be safe around them. These videos should promote public awareness of harmful algal blooms to people who use the waters, such as swimmers, boaters, fishers, or people who bring pets or livestock to the waters. Videos were judged on their messaging, scientific accuracy, educational value, and audio and video quality.

At this poster session, we will display the winning student video presentations about HABs and how they communicated effectively. We will also discuss challenges of communicating the risks of HABs to the public. Student videos that did not win but were submitted showed reasonable misunderstandings, like confusing phosphorus with potassium, confusion around cyanobacteria and algae, and understanding the appearance of HABs and surface vegetation. As a result, attendees will understand how to more effectively communicate issues around HABs.

Cyanobacterial Harmful Algal Bloom Outreach in Wisconsin: A Partnership Between the Wisconsin Department of Natural Resources and the Wisconsin Division of Public Health

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Cyanobacterial harmful algal blooms (CHABs) are of increasing interest and concern to the public in Wisconsin. The majority of Wisconsin's 14,000 lakes do not experience significant CHAB issues, but recurring problems in some eutrophic systems have led to growing awareness of CHAB impacts on lake users and homeowners. The Wisconsin Department of Natural Resources (WDNR) and the Wisconsin Division of Public Health (WDPH) are called on to provide information about statewide CHAB occurrence, health impacts, and management strategies to the public. WDNR and WDPH staff work closely with each other on CHAB information and outreach, ensuring messaging consistency between the two agencies. This cooperative approach grew out of the agencies' partnership which anchors the Wisconsin Harmful Algal Bloom Surveillance Program. The Wisconsin HAB Surveillance Program began in 2008 with a grant to the WDPH from the Centers for Disease Control and focuses on investigating CHAB-related illness complaints. Cooperative outreach efforts of the two agencies includes yearly presentations on CHAB identification, health impacts, and risk management at the Wisconsin Lakes Partnership Convention, annual CHAB webinars hosted by WDNR, presentations to local public health departments, lake associations, and summer camp groups, and collaborative work to develop outreach materials with information consistent across the two agencies.

A Design-Led Study: Using an Urban Lake As the Focus to Create Learning Opportunities in Cemetery Design

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In the modern era, cemeteries have been used not only for burials but also for parks for living citizens to enjoy. This study further investigated if a cemetery could have a third function – providing learning opportunities as an outdoor education facility.

In this study, a 150-acre site in Oklahoma, potentially designated to be a new cemetery development, was used to answer the above question. The design research process for the cemetery masterplan has focused on the two-acre urban lake on site, which was formed by natural stormwater runoff and drainage. The design study was carried out with three main components in mind: 1) the urban lake, 2) the surrounding natural resources that impact the lake's ecology, stormwater runoff, and wildlife, and 3) landscape restoration and preservation surrounding the lake. A series of vigorous design charrettes, presentations, reviews, and redesign activities have taken place. With the focus of the urban lake, the masterplan has proved that the cemetery can be the site to not only pay respects, but also be an educational campus in a park-like setting. Here children and students can learn multiple subjects including the lake, wildlife, natural resources, birds, stormwater, hydrology, and sustainability. This design-led process has proved that a cemetery can have the third function besides burials and parks – an outdoor educational facility. This type of cemetery development will provide profound educational value for the public, the municipal, students, and youth. This study lends insights for design professionals, cemetery development, lake usage, and city officials.

Monitoring Oregon's Drinking Water for Harmful Algal Blooms

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In spring of 2018, the City of Salem detected water passing through its public water facility and distribution system with concentrations of cyanotoxins exceeding a level of concern to vulnerable populations. For 33 days, vulnerable populations in Oregon's state capital were advised not to drink tap water. In response, the Oregon Health Authority (OHA), in consultation with the Oregon Department of Environmental Quality (DEQ), developed a rule for statewide monitoring of public water facilities deemed susceptible to HABs. This rule was made permanent in 2019 (Oregon Administrative Rule 333-061-0510). Drinking water monitoring under this rule currently takes place during the months of May through October. Additional monitoring takes place on an ongoing, as-needed basis to protect the health of the public, livestock, and pets from surface water recreational contact or ingestion exposure.

During the 2020 monitoring season, OHA and DEQ began conducting a study of the usefulness of quantitative polymerase chain reaction (qPCR) as an indicator and predictive tool for cyanotoxins in these susceptible drinking water systems. Current regulations in Oregon for routine testing for cyanotoxins at facility intakes provides important information on what is entering the treatment system, but testing is costly. Presently, the correlation between gene copies detected through qPCR and cyanotoxin concentrations is not well established in Oregon. If shown to be useful, qPCR may provide a less expensive, predictive, method for determining whether cyanobacteria have the genes necessary for producing cyanotoxins.

A Scalable Approach to Identifying All Fecal Sources of Contamination in Watersheds

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Sources of fecal indicator bacteria are difficult to identify in waterways where many different nonpoint sources may be responsible for contamination throughout the watershed. We developed a customizable microarray-based test based on the PhyloChip platform that detects and distinguishes fecal bacteria from humans, birds, dogs and cats, ruminants, horses, pigs and non-fecal environmental sources with a single assay.

The probe-based microarray test was applied to identify sources of fecal indicator bacteria in the Russian River and its tributaries. We found contamination by human sources during the wet season in lower reaches of the Russian River, due to failing septic systems in two separate communities. In addition, heavy recreational use in the dry season also caused human fecal contamination, likely due to bacterial shedding from beachgoers. Several samples that clearly contained human fecal bacteria did not exceed water quality thresholds for conventional FIB tests, some of which contained numerous Staphylococcus and other potential bacterial pathogens. These results indicate that conventional tests used for monitoring may fail to detect potential risks from fecal contamination and are less sensitive than detection based on thousands of molecular targets. All potential sources can be detected simultaneously, including sources for which no known or reliable markers exist. Additional applications include the addition of viral sequence-specific probes for community surveillance of potential pandemics in wastewater.

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American Water Lotus (*Nelumbo lutea*) Distribution and Status in Minnesota

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American water lotus (*Nelumbo lutea*) occurs in the eastern half of the United States and Minnesota is the northwestern edge of its range. This species is not listed as rare in Minnesota but anecdotal information suggests that some populations have declined. A recent genetic study (Islam *et al.* 2019) suggests that nationwide this species may be vulnerable due to low genetic variability.

I reviewed information from herbarium specimens, lake plant surveys, and photographic reports and identified a total of 39 Minnesota sites where American water lotus has been reported. Reports are restricted to 15 lakes in the Twin Cities greater metropolitan area and backwaters of the Minnesota River and lower Mississippi River. In the last 30 years, only four of these populations have been officially verified.

2020 field survey plans include visiting sites to document the presence and size of existing populations and to collect leaf material for a more robust genetic study of Minnesota's populations.

This poster will provide information on how to identify and help document American water lotus. This plant produces the largest flower of all Minnesota plant species but can be missed early in the summer or if flowers are not present. A look-a-like plant, *Nelumbo nucifera*, is native to Asia but commonly sold through the water garden industry. The introduction and spread of *N. nucifera* has been documented in other states and surveyors should be aware of how to distinguish it from *N. lutea*.

Water Treatment Innovation Using Floating Wetland Islands

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Floating wetland islands (FWI) are alternatives to watershed based constructed wetlands or similar to conventional vegetated best management practices (BMPs). FWIs are known to have many advantages in removing contaminants originating from various sources. The wetland mat and the aquatic plants in the mat remove pollutants such as sediments, nutrients, and organic materials in the water through physical operation, absorption, and utilization through the biosynthesis. The biofilm formed during the process provides a mechanism for adhesion.

The goal of this project was to test the efficacy of the floating wetland island to remove nutrients from water systems by only using plants and biofilm. We constructed floats from recycled computer packing frames and a water media filter with the intention of using waste to remove waste. The types of floatation utilized varied from concrete foundation insulation foam, plastic water bottles, styrofoam, and polyethylene packing foam. These materials were then put into small tanks and planted with the spiderwort. The floats were placed in bins filled with water collected from a pond on URI's campus. Water samples were tested for water quality parameters such as the Ph, Dissolved oxygen, phosphorous, and nitrates before and during the treatment. The water treated by the FWIs registered an average median pH of 6.35, while the control group without islands had an average median of 6.76. The result of the study indicated that NO_3^- N concentration of pond water reduced from the initial value of 4.4 ppm to 0.88 ppm within five weeks of treatment.

Transitioning From Planning to Implementation: Collaborating With Lake Associations to Take a Watershed Plan to the Individual Lake Level

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A Local Comprehensive Watershed Management Plan was completed in the Pine River Watershed of northern Minnesota in 2019. The planning process included public engagement of area lake associations, local mayors, business owners, and interested individuals. During the planning process lakes were prioritized and assigned a protection or enhancement focus based on water quality trends, phosphorus sensitivity, biological significance (supporting species such as Cisco and wild rice), and economic significance to the region. This prioritization narrowed the focus from over 500 lakes to 20 priority lakes. Goals were set for each priority lake for phosphorus reduction, land and shoreline protection, shoreline restoration, and groundwater protection. To transition from planning into implementation, individual lake management plans were developed for priority lakes. These seven-page lake management plans were designed as a public communication tool with input from the lake associations, so they are easy to use. Management goals specific to each lake are explained, along with an implementation table of how to reach the goals including what type of project, how many, who to contact for help, and the project cost and cost-share available. Research published by Concordia University reported that collectively, the 500+ Minnesota lake associations donate about 1.2 million hours and $6.25 million annually to lake conservation activities. These lake implementation plans with specific goals can help focus those resources and efforts to get a prioritized, targeted and measurable outcome for the lake. In addition, lake associations can take ownership in implementing the watershed management plan.

#Emergency Operations Plan for HAB Response Program

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Since 2010, the Harmful Algal Bloom Response Program at Kansas Department of Health and Environment (KDHE), in response to bloom reports, has issued advisories on a weekly basis from April-October each year. Advisories are normally based on cyanobacterial cell densities and toxin concentrations taken from shoreline water samples. During the 2020 COVID-19 pandemic, the Program faced significant staffing restrictions that affected both field capacity and analytical capacity. However, with outdoor recreation surging, especially among inexperienced lake visitors, it was critical to maintain a consistent advisory program. The agency therefore implemented an Emergency Operations plan, which relied heavily on partnerships with on-site Lake Managers from local, state, and federal agencies. Lake Managers took jar tests to confirm suspected blooms, submitted site photos from KDHE's standard sampling points, and sent written or verbal reports and map sketches describing the intensity and extent of the bloom. Using this structured visual and narrative evidence, KDHE was able to continue making consistent advisory determinations. In a few high priority situations, field staff were deployed for limited sampling, and Kansas Health and Environmental Laboratories provided toxin analysis using their analytical capacity developed to support public water supplies, with supporting data provided on a triage basis by KDHE's algal taxonomists. This adaptive response to an unprecedented situation is a testament to the value of strong interagency partnerships, creative team thinking, and a shared commitment to protect public and environmental health

Ecological HAB Control

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East Lake in Yorba Linda, California is a 15-acre lake surrounded by 191 homes and a large clubhouse. In 2013 East Lake contracted Gold Algae (*Prymnesium parvum*), a harmful algae resulting in a total fish kill. Copper sulfate was applied to treat the infestation though minimal improvements occurred leaving the lake in a condition unable to sustain a healthy fish population. Similarly, at Lago Santa Margarita, *Prymnesium parvum* had decimated the fish population. Eco Lake Solutions implemented a two-pronged strategy, beginning with Floating Wetlands. Floating Islands provide the matrix for beneficial plant root ecology. In this aerobic zone, the water is flushed through the roots of the plants and the associated beneficial bacteria. Observations have been made that during golden algae blooms fish move towards highly aerobic areas, where these floating islands would provide a safe haven for them. High efficiency aeration is the second component and creates "hydraulic flushing manipulation." This strategy has been proven successful in studies at Texas A&M Department of Wildlife and Fishery Science and Oceanography. At East Lake, using highly efficient aeration systems we are able to achieve the required flushing rates using three, 0.5 horsepower piston compressors with each unit pushing 12.5 million gallons per day though the treatment zones. Our hypothesis is not that the floating wetlands up-take the nutrients that cause the algae bloom. Rather the flushing of lake water through the healthy ecology of the root zones, associated periphyton and beneficial bacteria creates an alternative ecology that is able to out compete or displace the HAB or golden algae dominant environment.

Three years ago, Eco Lake Solutions installed a pilot in the eastern section of East Lake to manage golden algae in that pilot zone. The pilot was significantly more successful than expected in terms of improved water quality throughout the entire 15-acre lake. Since the installation of the natural ecological system, the lake has reported Golden Algae at non-detect and the aesthetics, odor and water quality have improved dramatically, and the fish population is thriving. At Lago Santa Margarita the fish population had been decimated by golden algae and nuisance algae causing odors and a high level of complaints from area residents. The installation of 22 islands and 11 diffusors was completed in December of 2018. In April 2019, the chlorophyll *a* concentration readings were half of that from April 2018 providing confidence to release fish in the lake in July of 2019. As of June 2020, the fish are healthy and recreational fishing has returned to the lake in addition to a marked improvement in the overall water aesthetics. Golden algae testing continues to come back at non detect and lake clarity is better than it has ever been according to longtime residents.

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

Combining an Innovative GIS Approach With Local Knowledge and Monitoring to Establish Phosphorus Reduction Strategies for at Risk Lakes in Agricultural Areas

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This approach links monitoring data, models, and implementation in an innovative way. West Leaf Lake is located West central Minnesota. The lakeshore is a mixture of development and forest and the drainage area of the lake consists of agricultural cropland and pastureland. During a watershed planning process, West Leaf Lake was prioritized for enhancement because it has a declining water quality trend based on long-term monitoring conducted by the lake association. A phosphorus reduction goal was set at 5% for the short-term (10 years) and 19% for the long-term, based on phosphorus modeling conducted by the Minnesota Department of Natural Resources. In order to determine how to reach the phosphorus goal, the Prioritize, Target, Measure Application (PTMApp) model was used to 1) identify where in the lake drainage area there was the most phosphorus transport, and 2) measure the phosphorus reduction benefits of implementing source reduction practices in those areas (*e.g.*, cover crops, reduced tillage, and nutrient management). The PTMApp model confirmed that the long-term phosphorus reduction goal could be met in the lake's drainage area. Next, the targeted locations for source reduction practices were overlaid with parcel information to identify specific landowners to work with. In implementation, the local Soil and Water Conservation District will work with the Lake Association and private landowners to install the best management practices to meet the phosphorus reduction goal for West Leaf Lake.