Poster Session Abstract Book

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***with the exception of abstract #18, which will be presented on Wednesday**

Poster Abstracts

1. Hossein ALILOU[1], Omid Rahmati[2], Fereshteh Kordrostami[3], Matthew Hipsey[1]

Assessment of groundwater discharge and temperature anomaly in Zarivar Lake

[1]Aquatic Ecodynamics, UWA School of Agriculture and Environment, The University of Western Australia, Crawley WA 6009, Australia
[2]Young Researchers and Elites Club, Khorramabad Branch, Islamic Azad University, Khorramabad, Iran
[3]Faculty of Natural Resources, University of Tehran, Iran

The present study demonstrates a practical and cost-effective approach for estimating lake surface temperature (LST) from Landsat data (using the ETM+ and OLI TIR waveband), highlighting the capability of the technique for a regional survey of potential groundwater discharge in data-scarce regions. The method was used to characterise Zarivar Lake, a fresh water shallow lake in the western of Iran. The current study involved three steps: first, driving LST from image processing to identify plumes of colder water during summer months from 2000 to 2018; second, mapping temperature anomalies using Geographical Information System (GIS); and third, field surveys to confirm the presence of groundwater. Results demonstrated that the spatial pattern of the mapped temperature anomaly had changed over the 18 years. These changes may be the result of dis-connection or closure of bottom springs due to the high rate of soil erosion and sedimentation experienced in the lake. This study provides practical recommendations for understanding GLEON lakes, and is particularly suitable when there is a lack of reliable in situ data collection of temperature or regional-scale assessment of groundwater discharge.

2. *Maggie ARMSTRONG[1], Elisabeth Ruijgrok[2], Lisette de Senerpont Domis[1], Lennart Turlings[2]*

The People Behind The Process: Water Authority Socioeconomic Decisions in the Implementation of the Water Framework Directive

[1]Aquatics Department, Netherlands Institute of Ecology, Wageningen, The Netherlands
[2]Ecology Department, Witteveen+Bos, Deventer, The Netherlands

Climate-driven compounding of freshwater challenges are highlighting the need for multidisciplinary, proactive management approaches. The European Union's Water Framework Directive has already demonstrated a change in traditional water management thinking by requiring aquatic ecosystems to achieve "good" ecological status. Water authorities charged with this task are granted flexibility when developing region-specific remediation plans, fostering the possibility of there being many distinct methodologies implemented across the European Union. Presently there are no requirements for water authorities to report the steps that are taken when developing their river basin district Programme of Measures. However, due to the impact that freshwater system functions have on human communities, we theorize that authorities are considering ecosystem services and uses in their decisions. To (1) understand their chosen methodology, (2) ascertain the role of socioeconomic values in the decision-making process and (3) evaluate the effect on ecological status, we will conduct interviews with water authorities throughout the EU. Supplementary information on initial ecological states, ecosystem analyses results and end ecological states will be acquired from the Directive implementation reports. We will analyze the data for trends with the improvement of ecological status and the inclusion of socioeconomic values. We anticipate that authorities will filter out potential remediation measures first by their effect on major water body uses and then by economic evaluation. Communication of our findings will assist in the knowledge sharing amongst water authorities and can lead to the integration of ideas from another organization's planning process.

3. *Karen S. ATKINS[1], Derek C. Roberts[1], S. Geoffrey Schladow[1]*

Drivers of Periphyton Biomass in an Oligotrophic Lake

[1]Tahoe Environmental Research Center, University of California, Davis, California, USA

Periphyton, attached algae at the boundaries of freshwater environments, plays important ecological roles as the base of many aquatic food webs and as indicator species. The periphyton biomass and taxonomy at a particular location is dependent on a range of physical, chemical, and biological variables. These variables result in high spatial and temporal, underscoring the need for an understanding of the processes that control periphyton dynamics. An experiment designed to compare limnetic versus littoral and benthic versus pelagic processes on periphyton was used to better understand the complex systems influencing lacustrine periphyton. Artificial substrate surfaces were deployed for periphyton growth along seven moorings in Lake Tahoe, USA. The substrates were located at a range of depths and distances from shore. In addition, frequent measures of temperature, photosynthetically active radiation, total reactive phosphorous, phosphate, nitrate, and ammonia were gathered near the artificial substrate. After two months the substrate was retrieved and assessed for taxonomy, chlorophyll-*a* content, and biomass. The results of this experiment provide unique data on the establishment and growth of periphyton biomass and its speciation in Lake Tahoe within a spatial context. To place observations of grazing and sloughing processes within the context of other periphyton biomass drivers I utilize nutrient, light, and temperature data. Results will be used to calibrate and validate a periphyton biomass model for Lake Tahoe.

4. *Ana I. AYALA[1], Don Pierson[1]*

Simulation of the effects of the climate change on Lake Erken thermal structure

[1]Department of Ecology and Genetics/Limnology, Uppsala University, Sweden.

The goal of this study, as part of the Inter-Sectoral Impact Model Intercomparison Project (https://www.ISIMIP.org), is to assess the impacts of different levels of global warming on the thermal structure of Lake Erken (Sweden). These are the first site specific simulations made for the ISIMIP lake sector, and allow us test of the methodologies that will be used for a larger set of simulations that will be run using a global lake data set (~50 lakes). For this purpose, a one dimensional-hydrodynamic model (GOTM) is used to simulate water temperature when driven with input meteorological scenarios supplied by ISIMIP.

The input meteorological simulation data has a daily time step, while lake model simulations are often forced with data at hourly or shorter time steps. Therefore, it was necessary to systematically test the ability of the GOTM model to simulate Lake Erken water temperature using daily vs hourly meteorological forcing data, and also using a daily vs hourly computational time step. We also compared water temperature results obtained using synthetic hourly meteorological forcing data created from daily meteorological forcing data using Generalized Regression Artificial Neural Network methods. In all the cases the GOTM model was calibrated based on the comparison of over 56000 simulated and measured mean daily water temperature measurements during the period from 2006 to 2016.

Long-term water temperature simulations focus on quantification of impact of historical warming and climate change effects based on two future projections: one for moderate-mitigation (rcp6.0) and another for strong-mitigation (rcp2.6), and evaluate these relative to preindustrial conditions (piControl).

5. *Sarah L. BARTLETT[1], Melanie Perello[2], Robyn Smyth[3], Lisa Borre[4]*

Cyanobacterial harmful algal blooms increasing in severity: Perception vs. Reality

[1]School of Freshwater Sciences, University Wisconsin-Milwaukee, USA
[2]Dept. Earth Sciences, Indiana University, USA
[3]Bard Center for Environmental Policy, Bard College, USA
[4]Cary Institute of Ecosystem Studies, USA

Cyanobacterial harmful algal blooms (cyanoHABs) are increasing in severity and frequency and are a worldwide problem. On an individual scale, lakes may be increasing or decreasing in severity and duration of cyanoHABs and it is possible that a person's relationship with the lake, e.g. scientist, lake manager, or stakeholder, may play a role in their perception of cyanoHAB severity. A survey of two different organizations, the Global Lake Ecological Observatory Network (GLEON) and North American Lake Management Society (NALMS), asked respondents in-depth questions on lake eutrophication and cyanoHABs, in addition to questions related to the person's history and role with the lake. Several lakes overlapped between the two organizations. The survey investigated a person's perception of the lake compared to available data to refute or confirm their survey responses. In many cases, data are not available on cyanoHABs for individual lakes as the survey investigated responses for145 GLEON lakes and 68 NALMS lakes. However, this survey offers important insight into a problem many lake managers face and provides a unique comparison of perception between the various roles people have with their lakes.

6. *Laura M. Gagliardi[1], Ludmila S. Brighenti[1], Peter A. Staehr[2], Francisco A. R. Barbosa[1], José F. BEZERRA-NETO[1]*

Reduced precipitation increases metabolic rates in upper mixed layers of tropical clear-water lakes

[1]Limnea, Federal University of Minas Gerais, Belo Horizonte, Minas Gerais, Brazil
[2]Aarhus University, Department of Bioscience, Roskilde, Denmark.

We investigated the effects of reduced precipitation during a rainy season on the internal chemical, biological and physical drivers of primary production and respiration in 12 tropical lakes differing in morphometry and catchment properties. These lakes are located in the middle Rio Doce Basin, Minas Gerais (Brazil). An 80% reduction in the 2013 rainy season precipitation, compared with 2012, resulted in a reduction of approximated 1m in the water column depth, a 1-2m m deepening of the upper mixed layer, a 50% reduction in mean light availability, and a doubling in total phosphorous concentrations. Those changes were associated with 38% increases in gross primary production (GPP) at the upper mixed layer, likely stimulated by higher nutrient concentrations and reduced photoinhibition. The epilimnetic GPP during the 2013 unusual rainy season was similar to levels normally occurring in the more productive dry season. These effects of reduced precipitation were strongest in small lakes in relation to their catchment areas. Our results suggest that expected climate change in this tropical region will reduce lake volumes resulting in higher internal loadings of nutrients, increased turbidity of the water column and higher GPP and R rates in the upper mixed layer during summer stratification.

7. *Jennifer A. BRENTRUP[1], David C. Richardson[2], Cayelan C. Carey[3], Nicole K. Ward[3], Denise A. Bruesewitz[4], Kathleen C. Weathers[5]*

The importance of ice-on and ice-off periods for driving under-ice metabolism dynamics in an oligotrophic lake

[1]Department of Biological Sciences, Dartmouth College, Hanover, New Hampshire, USA
[2]Biology Department, SUNY New Paltz, New Paltz, New York, USA
[3]Department of Biological Sciences, Virginia Tech, Blacksburg, Virginia, USA
[4]Environmental Studies Program, Colby College, Waterville, Maine, USA
[5]Cary Institute of Ecosystem Studies, Millbrook, New York, USA

The under-ice environment of lakes is an under-sampled time period, but with the recent advancement of automated sensors, it is becoming easier to capture winter biological dynamics. Ecosystem metabolism is an integrative measure of autotrophic and heterotrophic processes, and a sensitive indicator of changes in trophic status. However, ecosystem metabolism has rarely been modeled under-ice, including the transition periods immediately following the beginning and end of ice cover. Using a continuous year of high-frequency dissolved oxygen data from an oligotrophic lake, our goal was to understand the patterns of ecosystem metabolism under-ice and how they compared to the open-water period. As winters warm, the ice-on and ice-off periods of thin or intermittent ice cover are likely to increase, so we also focused on comparing ecosystem metabolism in these transitions to the stable under-ice period. For the entire winter, we found that on average net ecosystem production (NEP) was net heterotrophic, which differed from the summer, spring and fall estimates where NEP was net autotrophic. During the under-ice period, respiration (R) rates were 2x higher than the summer stratified period and remained high during the ice-off transition phase. Gross primary production (GPP) rates were low during the stable under ice period but increased over the winter during the ice-off transition and spring mixing period. Our findings highlight the importance of sampling year-round to capture rapid changes in R and GPP and including winter metabolism estimates flipped annual NEP from net autotrophy to slight net heterotrophy.

8. *Maria CALDERO PASCUAL[1], Eleanor Jennings[1], Elvira deEyto[2], Mary Dillane[2] and Valerie McCarthy[1]*

Annual nutrient dynamics in the Burrishoole catchment to describe the drivers of ecosystem productivity

[1]Centre for Freshwater and Environmental Science, Dundalk Institute of Technology, Dundalk, Co. Louth, Ireland.
[2]Marine Institute, Furnace, Co. Mayo, Ireland.

The Burrishoole catchment is situated on the northwest Atlantic coast of Ireland in Country Mayo and consists of approximately 90Km^2 of mainly blanket bog. The Burrishoole catchment is a GLEON site and has a network of *in-situ* sensors which measure a range of variables in near real time. The well-developed monitoring program allows for a better understanding of the physical, chemical and biological dynamics of the system to be developed.

The focus of this work is on Lough Feeagh, which is an oligotrophic, humic lake with a maximum depth of 48 meters (mean depth 14m) and residence time of 0.47 years with an area of 4Km^2. The principal aim is to address the gap in the current monitoring programme for Lough Feeagh by quantifying macro-nutrient concentrations through the monitoring of major nutrient fractions (carbon (C), nitrogen (N), and phosphorus, (P)), in order to gain a better understanding of the drivers of productivity. The current high frequency monitoring (HFM) system in Lough Feeagh has been augmented by the addition of a new dissolved nitrogen sensor at one of the inflows. In addition, fortnightly grab samples from three inflow rivers to Lough Feeagh, two outflows and the lake have been carried out to monitor seasonal nutrient dynamics. The sampling campaign takes into account water and particulate nutrient fractions as well as phytoplankton and zooplankton quantification and identification.

In addition to informing on the nutrient loading and cycling, the next stage of this work aims to establish the relative importance of seasonal allochthonous versus autochthonous contributions to ecosystem production. Humic systems such as Burrishoole tend to be characterised by high allochthonous (terrestrial) C sources, leading to low light conditions and the promotion of high bacterial production at the expense of phytoplankton production, this has potential implications for food quality for higher trophic levels. In order to provide a reliable evaluation of potential effects on food web structure and ecosystem productivity, the partitioning of carbon and other nutrients between different trophic compartments will be measured on a monthly basis and related to light and the availability of dissolved nutrients.

9. *Cayelan C. CAREY[1], R. Quinn Thomas[2], Renato J. Figueiredo[3], Vahid Daneshmand[3], Bethany J. Bookout[1], Francois Birgand[4]*

Integrating environmental sensor networks and real-time ecological forecasting to adaptively manage water quality

[1]Department of Biological Sciences, Virginia Tech, Blacksburg, Virginia, USA
[2]Department of Forest Resources & Environmental Conservation, Virginia Tech, Blacksburg, Virginia, USA
[3]Department of Electrical and Computer Engineering, University of Florida, Gainesville, Florida, USA
[4]Department of Biological and Agricultural Engineering, North Carolina State University, Raleigh, North Carolina, USA
[5]Department of Geosciences, Virginia Tech, Blacksburg, Virginia, USA

Freshwater ecosystems around the globe are facing unprecedented levels of anthropogenic stress, resulting in increased toxic phytoplankton blooms, metal contaminants, and low oxygen concentrations that threaten water quality. To ensure safe drinking water in the face of global change, managers need real-time environmental data and ecological forecasts to detect and predict when water quality thresholds are crossed so they can act rapidly to mitigate threats. In response, we have developed a "smart water system" by embedding a secure, wireless sensor network in Falling Creek Reservoir, a drinking water reservoir in Roanoke, Virginia, USA, to improve water quality and freshwater management. High-frequency data on reservoir hydrodynamics, chemistry, and algal conditions collected by novel sensor technology are being used to create real-time water quality forecasts for drinking water managers. The sensor data update daily simulations of an open-source water quality model running in the cloud to create 15-day forecasts that will be autonomously published with digital object identifiers and searchable through the Environmental Data Initiative repository. These forecasts are being co-designed in partnership with Roanoke's water utility to ensure that they successfully translate water quality model output into decision support tools useful to managers. Preliminary forecasts developed from the smart water system to date demonstrate that the model can successfully predict changes in water temperature and thermal stratification due to storm-driven mixing events, which has provided important information to managers on which depths to withdraw water from the reservoir for drinking. By developing new network computing methods for connecting distributed sensors and cloud infrastructures through virtual private networking; generating new computational methods for automated model-data fusion; and providing greater understanding of how global change and management interact to control water quality, we envision that our smart water system will serve as a prototype for ecological forecasting systems in other drinking water supply lakes and reservoirs globally.

10. Liah X COGGINS[1] and Anas Ghadouani[1]

High-resolution bathymetry mapping of the Rottnest Island salt lakes

[1]Department of Civil, Environmental and Mining Engineering, The University of Western Australia, Crawley, Western Australia

Prior to 2015, there had never been a bathymetry survey conducted on the Rottnest Island salt lakes. These salt lakes are of significance to the ecosystem of the island, and historical value. In collaboration with the Rottnest Island Authority, we deployed a remote control boat equipped with sonar to profile the lake bathymetry. This poster will present the results of the survey, and discuss the implications of the findings.

11. *Jonathan P. DOUBEK[1], Rita Adrian[2], Orlane Anneville[3], Ruchi Bhattacharya[4], Elvira de Eyto[5], Heidrun Feuchtmayr[6], Josef Hejzlar[7], Bastiaan W. Ibelings[8], Stéphan Jacquet[9], María E. Llames[10], Shin-ichiro S. Matsuzaki[11], Peeter Nõges[12], Vijay P. Patil[13], Alon Rimmer[14], Lars G. Rudstam[15], Michael J. Vanni[16], Piet Verburg[17], Tamar Zohary[14], Jason D. Stockwell[1]*

The extent and variability of storm-induced epilimnetic temperature changes in lakes using a long-term and high-frequency global dataset

[1]University of Vermont, Rubenstein Ecosystem Science Laboratory, Burlington, Vermont, USA
[2]Leibniz Institute of Freshwater Ecology and Inland Fisheries, Department of Ecosystem Research, Berlin, Germany
[3]Institut National de la Recherce Agronomique, Thonon-les-Bains, France
[4]University of Missouri, Columbia, School of Natural Resources, Columbia, Missouri, USA
[5]Marine Institute, Fisheries Ecosystems Advisory Services, Newport, Co. Mayo, Ireland
[6]Lake Ecosystems Group, Centre for Ecology & Hydrology, Lancaster Environment Centre, Lancaster, UK
[7]Biology Centre of the Czech Academy of Sciences, Institute of Hydrobiology, České Budějovice, Czechia
[8]University of Geneva, Department F.-A. Forel for Aquatic and Environmental Sciences and Institute for Environmental Sciences, Geneva, Switzerland
[9]Equipe de Microbiologie Aquatique, Station INRA d'Hydrobiologie Lacustre, UMR CARRTEL, Thonon Cedex, France
[10]IIB-INTECH-UNSAM-CONICET, Laboratorio de Fotobiología y Ecología Acuática, Buenos Aires, Argentina
[11]National Institute for Environmental Studies, Center for Environmental Biology & Ecosystem Studies, Ibaraki, Japan
[12]Estonian University of Life Sciences, Institute of Agricultural and Environmental Sciences, Tartu, Estonia
[13]US Geological Survey, Alaska Science Center, Anchorage, Alaska, USA
[14]Israel Oceanographic & Limnological Research, Kinneret Limnological Laboratory, Migdal, Israel
[15]Cornell University, Natural Resources, Ithaca, New York
[16]Miami University, Department of Biology, Oxford, Ohio, USA
[17]National Institute of Water and Atmospheric Research, Hamilton, New Zealand

The intensity, frequency, and duration of storms are expected to increase in many regions around the world because of climate change. Altered environmental conditions following storms can lead to shifts in the composition and variability of ecological communities across terrestrial and aquatic ecosystems. In freshwater lakes and reservoirs, storms can rapidly lower surface water temperatures in several ways including precipitation run-off and wind-induced water column mixing of the epilimnion and the hypolimnion. Decreased water column temperatures could subsequently impact phytoplankton community structure. Recent laboratory experiments suggest that sharp and rapid changes in water temperature (10ºC) could influence phytoplankton communities more than storm-induced increases in nutrients and decreases in light. We empirically assessed the extent to which epilimnetic

temperatures change after storm events, and how any changes may depend on various environmental conditions or morphometric characteristics such as season, lake mixing regime, and origin of the waterbody. We analyzed high-frequency, and long-term datasets from a global set of lakes from the Global Evaluation of the Impacts of Storms on freshwater Habitat and structure of phytoplankton Assemblages (GEISHA), originated within GLEON Storm-Blitz, to (1) estimate the degree to which storms lower epilimnetic temperatures, (2) test if the largest epilimnetic temperature decreases were associated with the strongest storm events, and (3) quantify what internal or external characteristics of lakes play significant roles in the extent of epilimnetic temperature changes. Finally, we discuss the implications of observed changes in epilimnetic temperature as a result of storms for phytoplankton community dynamics, using functional trait approaches.

12. Kaitlin J. FARRELL[1], and Cayelan C. Carey[1]

Macrosystems EDDIE: Building Computational Literacy and Macrosystems Ecology Knowledge through Hands-On Teaching Modules

[1]Department of Biological Sciences, Virginia Tech, Blacksburg, Virginia, USA

Ecological research increasingly requires understanding drivers and responses that operate at multiple, interconnected spatial and temporal scales. To understand complex ecological feedbacks, a macrosystems approach has emerged that uses high-frequency data and simulation models to predict how ecosystems respond to changes in drivers at multiple scales. Despite the increasing use of these research approaches, however, undergraduate ecology curricula rarely include concepts in macrosystems ecology or simulation modeling and other advanced computational skills. Through Macrosystems EDDIE (Environmental Data-Driven Inquiry & Exploration; MacrosystemsEDDIE.org), we are developing a suite of hands-on, data-driven modules that instructors can use to introduce fundamental macrosystems topics to undergraduate students at a range of experience levels. Modules combine high-frequency data from GLEON lakes with the General Lake Model (GLM-AED) to guide students through inquiry-based lessons on macrosystems topics through the lens of limnology. To date, we have tested our modules at 11 universities worldwide and found that modules significantly increased students' self-reported knowledge of ecosystem simulation modeling and macrosystems ecology relative to their pre-module knowledge. In addition, module use led to increased student confidence and perceived proficiency using a suite of computational tools. Finally, using simulation models to develop and test hypotheses increased both students' perceptions of the value of high-frequency environmental data and their ability to use models to predict climate change effects on ecosystems. These results suggest that integrating simulation modeling activities, like Macrosystems EDDIE modules, into undergraduate ecology curricula will enhance students' abilities to interpret complex and non-linear dynamics in ecosystems. We are currently soliciting additional faculty testers of our modules and encourage you to contact the Macrosystems EDDIE team if you are interested.

13. *Evelyn E. GAISER[1], Hilary Swain[2], Ileana Corsi[1], Kristin Dominguez[1], and Emily Nodine[3]*

Cyclical environmental determinism in phytoplankton assembly in Lake Annie, Florida

[1]Department of Biological Sciences, Florida International University, Miami, Florida, USA
[2]Archbold Biological Station, Venus, Florida, USA
[3]Department of Environmental Studies, Rollins College, Winter Park, Florida, USA

Limnologists have long recognized a strong regulatory role of abiotic drivers in controlling the seasonal development of phytoplankton communities, and GLEON scientists have been quantifying how physical factors interact with biological processes to determine seasonal phytoplankton assembly at novel spatio-temporal scales. These studies challenge the fundamental concept of seasonal phytoplankton development in some lakes, especially those faced with non-stationary climate drivers. A case study is Lake Annie, Florida - a monomictic, subtropical, oligotrophic lake exhibiting erratic phytoplankton dynamics. Analysis of a long-term monthly limnological record helped define a strong role of a multi-decadal climate cycle, the Atlantic Multidecadal Oscillation, in regulating the lake's physical dynamics. This cycle is characterized by 20-30 year periods of low rainfall (cool AMO) oscillating with periods of higher and more stochastic rainfall (warm AMO). In the context of GLEON projects, we are testing whether this heterogeneity in a key environmental driver of lake physics drives predictability of plankton succession. We found that while phytoplankton assemblage composition does not follow a repeatable seasonal pattern, summer assemblages are more similar and predictable in cold AMO than warm AMO years, suggesting a cyclical pattern of environmental determinism of phytoplankton assembly. Assemblages in years with high rainfall (warm AMO) exhibit greater trait diversity, including algae with alternative energy acquiring pathways to photosynthesis (mixotrophs). We hope to develop a generalizable model for understanding phytoplankton assembly in lakes driven by stochastic physical processes, a common feature of (sub)tropical lakes, for improving both forecast and hindcast (paleo-prediction) models of phytoplankton dynamics.

14. Anas GHADOUANI[1] and Liah X Coggins[1]

High-resolution bathymetry mapping of water bodies: Application in waste stabilisation ponds

[1]Department of Civil, Environmental and Mining Engineering, The University of Western Australia, Crawley, Western Australia

Traditionally, bathymetry mapping of ponds, lakes and rivers have used techniques which are low in spatial resolution. Waste stabilisation ponds (WSPs) are utilised worldwide for wastewater treatment, and throughout their operation require periodic sludge surveys. Traditionally, sludge heights, and thus sludge volume, have been measured using techniques such as the 'sludge judge' and the 'white towel' test. Both of these methods have low spatial resolution, are subjective in terms of precision and accuracy, are labour intensive, and require a high level of safety precautions. A sonar device fitted to a remotely operated vehicle (ROV) can improve the resolution and accuracy of sludge height measurements, as well as reduce labour and safety requirements. This study aimed to design, build, and assess the performance of an ROV to measure sludge height in WSPs. Profiling of several WSPs has shown that the ROV with autonomous sonar device is capable of providing bathymetry with greatly increased spatial resolution in a greatly reduced profiling time. To date, the ROV has been applied on in excess of 400 WSPs across Australia, several large lakes, stormwater retention ponds, river beds, and drinking water reservoirs. As demonstrated, this technology is not limited to application in wastewater management, with the potential for wider application in the monitoring of other small to medium sized water bodies, including reservoirs, lakes, channels, recreational water bodies, river beds, mine tailing dams and commercial ports.

15. Malgorzata GOLUB[1], Don Pierson[1], Wim Thiery[2], Rafael Marcé[3], Fang Zhao[4]

ISIMIP2b Lake Sector: Predicting Climate Change Impact on Lakes with Ensemble Hydrodynamic Models

[1]Uppsala University
[2]Vrije Universiteit Brussel
[3]Catalan institute for Water Research
[4]Potsdam Institute for Climate Impact Research

Freshwater lakes provide numerous ecosystem services, are both sensitive indicators of climate change and hot spots of biogeochemical processing, affecting the energy and gas exchanges, and energy balance of the surrounding landscape. emerging evidence indicates that lakes have been affected and continue to be affected by changing climate, with consequent changes in water temperature, thermal structure and biogeochemistry. Here we will present the initial results of GLEON-ISIMIP project aiming at projecting the climate change impacts on lake ecosystems under 2°C and 3°C global warming scenarios. Nearly 40 scientists will perform the ensemble model simulations in the ISIMIP Lake Sector to quantify differences in climate-change impacts on lake hydrodynamics with ensemble simulations runs of 8 uncalibrated global and 9 calibrated local models. The climate impact on 16000 (global) and 60 (local) lakes will be evaluated to discern climatic effects under strong (RCP2.6) and minimal (RCP6.0) mitigation measures relative to pre-industrial levels. We will present the results of global-local model performance intercomparison and spatiotemporal patterns of change in water temperature, mixed layer dynamics, and ice dynamics. First results with the Community Land Model version 4.5 (CLM4.5) highlight that globally-averaged lake temperatures at 2m depth may warm up to 2.5 °C compared to pre-industrial levels under RCP6.0, consistent with projected atmospheric warming rates. The project outcomes will provide the basis for understanding how lacustrine systems will respond to anthropogenic climate change and contribute to the consistent cross-sectoral assessment of projected impacts on ecosystems and human society.

16. Emma GRAY[1, 2], Ian D. Jones[1], J. Alex Elliott[1], Eleanor B. Mackay[1] and Andrew M. Folkard[2]

Distinguishing the separate impacts of water temperature and mixed depth change on the phytoplankton community of a small eutrophic lake

[1]Centre for Ecology & Hydrology, Lancaster Environment Centre, Lancaster, UK
[2] Lancaster Environment Centre, Lancaster University, Lancaster, UK

Lake water temperatures are changing with climate. Changes in water temperature are inherently linked to the mixed depth of a lake and the onset and duration of lake stratification. Shifts in these physical factors impact phytoplankton growth in different ways, with temperature controlling growth rates, the mixed depth controlling the light climate and stratification determining water column stability and the length of the growing season. The ability of a phytoplankter to respond to these changes will depend on their growth rates, morphology and motility. One concern is that higher water temperatures and shallower mixed depths will favour buoyant cyanobacteria. Disentangling the impacts of these physical factors on phytoplankton growth and community change is difficult from observed data. Using a phytoplankton community model (PROTECH) we systematically changed the water temperature and mixed depths using a 3-year period of high resolution data from a small eutrophic lake in the UK, whilst keeping the length of stratification and nutrient loading the same. The largest changes to the phytoplankton community occurred when both temperature and the mixed depth were changed. There was an increase in cyanobacteria concentrations at the highest temperature increases at both shallow and deep mixed depths. Shallow mixed depths and higher water temperatures increased the dominance of buoyant *Dolichospermum* whereas the low light adapted *Planktothrix* dominated at deeper mixed depths and higher temperatures.

17. Claire HERBERT[1], Greg McCullough[1], David Barber[1]

A comparison of satellite-derived versus in-situ chlorophyll and TSS values on two Manitoba Great Lakes

[1]Center for Earth Observation Science, University of Manitoba, Winnipeg, MB, Canada

Millions of dollars are spent each year in Canada on protecting waterways from urban and agricultural pollutants, including excess nutrients and keeping fisheries healthy. Increasingly limited funding of federal and provincial agencies charged with environmental protection has led to reduced temporal and spatial water quality monitoring in Manitoba, so that lake management is increasingly based on insufficient data.

The waters of Lakes Winnipegosis and Manitoba are Case II waters, meaning their optical properties are influenced not only by phytoplankton (chlorophyll-a) but also by total suspended sediments (TSS) and coloured dissolved organic matter (CDOM). Large areas in these lakes are very shallow, so that either bottom reflectance (depths vary from 2 - 9 meters) or submersed vegetation add more complexity, making it difficult to monitor chlorophyll-a and TSS with both precision and accuracy. In other large lakes in the Canadian prairies (e.g. Lake Winnipeg and Lake of the Woods), local calibration using *in situ* data has been useful for retrieval of these parameters.

To improve algorithms for monitoring these parameters by satellite remote sensing, we have collected surface and bottom water quality data in Lakes Manitoba and Winnipegosis. Over the last two years we have sampled at XX stations throughout these lakes three times per year (spring, summer and fall) to capture a variety of open water conditions. At selected sites we used a field spectrometer (ASD fieldSpec Pro) to measure surface reflectance over the spectral range used by ocean colour satellites, and analyzed matched water samples for chlorophyll, TSS, CDOM and major algal groups (by microscopy). SNAP software (Eurosat MERIS and OLCI analysis software) was used to calculate surface reflectance data and physical products (apig, chlorophyll concentrations, spm) from matched Sentinel-3 OLCI images. This data was compared with *in situ* chlorophyll and TSS as a preliminary investigation of the suitability of OLCI for optical monitoring in these great lakes.

18. Claire HERBERT[1], Greg McCullough[1], David Barber[1]

The Canadian Watershed Information Network – a repository for freshwater and marine data in the Hudson Bay Watershed

[1]Center for Earth Observation Science, University of Manitoba, Winnipeg, MB, Canada

The Canadian Watershed Information Network (CanWIN) is an open access repository for freshwater and arctic research datasets. It is hosted by the Centre for Observation Science (CEOS) at the University of Manitoba, Winnipeg, MB.

CanWIN was developed and hosted originally by Environment and Climate Change Canada. In 2013 it was transferred to the UM. The CanWIN project has evolved from a data storing system into a research lifecycle management system. CanWIN works with the UM libraries and researchers to provide tools to facilitate the planning, collection, analysis, sharing and archiving of data.

Data repositories face many challenges, from maintaining stable sources of funding to navigating the complex world of metadata standards, semantic vocabulary and data transformation. They should therefore not work in isolation but strive to coordinate .and share tools and resources where possible. To this end, CanWIN has developed partnerships with both arctic and freshwater organizations to standardize and facilitate the development of vocabulary, metadata and data harvesting tools and methods.

In this poster, we describe the revamped framework for CanWIN, the research flow from proposal to data archiving and some of the challenges and lessons learned along the way.

19. *Allison HRYCIK[1], Don Pierson[2], Peter Isles[3], Rita Adrian[4], Matt Albright[5], Linda Bacon[6], Ruchi Bhattacharya[7], Stella Berger[4], Hans Peter Grossart[4,8], Josef Hejzlar[9], Amy Hetherington[10], Stephan Jacquet[11], Lesley Knoll[12], Alo Laas[13], Noah Lottig[14], Cory McDonald[15], Kellie Merrell[16], Jens Nejstgaard[4], Kirsten Nelson[17], Peeter Nõges[13], Andrew Paterson[18], Rachel Pilla[19], Dale Robertson[20], Lars Rudstam[21], Jim Rusak[18], Steven Sadro[22], Eugene Silow[23], Jason Stockwell[1], Huaxia Yao[18], Kiyoko Yokota[5]*

Effects of Runoff Timing on Severity of Summer Algal Blooms

[1]Rubenstein Ecosystem Science Laboratory, University of Vermont, Burlington, Vermont, USA
[2]Uppsala University, Uppsala, Sweden
[3]Umeå University, Umeå, Sweden
[4]Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany
[5]State University of New York College at Oneonta, Oneonta, New York
[6]Maine Department of Environmental Protection, Augusta, Maine, USA
[7]University of Missouri, Columbia, Missouri, USA
[8]Institute of Biochemistry and Biology, Potsdam University, Germany
[9]Biology Centre CAS, Institute of Hydrobiology, České Budějovice, Czech Republic
[10]Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA
[11]UMR CARRTEL, Station INRA d'Hydrobiologie Lacustre, Thonon-les-Bains, France
[12]University of Minnesota Itasca Station, Lake Itasca, Minnesota, USA
[13]Estonian University of Life Sciences Centre for Limnology, Tartu, Estonia
[14]Trout Lake Station, Center for Limnology, University of Wisconsin–Madison, Boulder Junction, Wisconsin, USA
[15]Michigan Technological University, Houghton, Michigan, USA
[16]Vermont Department of Environmental Conservation, Montpelier, Vermont, USA
[17]New Hampshire Department of Environmental Services, Concord, New Hampshire, USA
[18]Dorset Environmental Science Centre, Ontario Ministry of the Environment and Climate Change, Dorset, Ontario, Canada
[19]Miami University, Oxford, Ohio, USA
[20]United States Geological Survey, Middleton, Wisconsin, USA
[21]Cornell Biological Field Station, Department of Natural Resources, Cornell University, Bridgeport, New York, USA
[22]Department of Environmental Science and Policy, University of California, Davis, California, USA
[23]Institute of Biology, Irkutsk State University, Irkutsk, Russia

Winter conditions are hypothesized to set the stage for aquatic communities for the rest of the year, including the severity of harmful algal blooms. However, little is known about how winter physiochemical conditions influence summer phytoplankton

dynamics in light of a changing climate. We expect that nutrients delivered to lakes during colder, deeply mixed, and possibly ice-covered conditions, could be less effective at stimulating phytoplankton growth because of early loss through lake outflow, sedimentation, uptake by other organisms, such as heterotrophic bacteria, or uptake by diatoms which may transport nutrients to the hypolimnion. Additionally, earlier snowmelt may correspond with shorter periods of daylight, thus causing a mismatch between nutrient inputs and light levels necessary to promote phytoplankton growth. We developed an index of winter/spring runoff timing using the center of mass of stream discharge for inflows, outflows, or nearby streams for approximately 40 lakes in Europe and North America. Each year, the runoff index is paired with an index of summer productivity using long-term chlorophyll a data for each lake. Results indicate that earlier runoff timing generally corresponds to lower summer productivity. We examined several covariates that may regulate the relationship between runoff timing and productivity, including residence time, lake area, watershed area, lake depth, and trophic status.

20. Michael L. HUGHES[1], Randy Turner[2]

Synoptic limnology and monitoring of Upper Klamath Lake, Oregon, USA: implications for management and restoration

[1]Oregon Institute of Technology
[2]Klamath Basin Monitoring Program

Upper Klamath Lake is one of the most eutrophic, politically contested, and intensively monitored lake systems in the world. Sampling and analysis of the lake and its tributaries, beginning in the 1990's and continuing to the present, has yielded a number of key insights into the lake's ecology, nutrient cycles, and potential future status. These insights include: (1) since the late 19th century, agricultural land use has increased loading of macronutrients, most importantly phosphorus, from various sources connected, but considered external, to the lake, (2) this loading is retained and internally cycled within the lake over time as "new" loading from external sources continues, (3) eutrophication dynamics vary from year-to-year but overall water quality continues to deteriorate, as evidenced by elevated pH, anoxia/hypoxia, and intensification of toxic cyanobacteria blooms, and (4) poor water quality conditions are at least the proximal cause of a protracted decline and recent die-offs of two native species of suckers listed under the U.S. Endangered Species Act, and (5) a reduction of external loading of phosphorus by 40% is needed to achieve water quality standard set under the U.S. Clean Water Act and provide conditions likely to support healthy, naturally self-sustaining populations of suckers. Recent responses have emphasized enhancement and restoration of riparian wetlands along tributaries and lakeshores, with at least two distinct strategies. The first is to construct or re-establish riparian wetlands to collect, retain, and treat non-point source nutrient runoff from agricultural lands. The second is to reduce and treat pumped discharge of water from canals and other waterways that drain former lake-fringe wetlands that have been converted to arable land. The two strategies are considered mutually compatible at field scale, yet uncertainty remains about the degree to which these strategies can ultimately improve water quality of the lake, the time required for the lake to process stored nutrients as external loading decreases, how to best cooperate with agricultural landowners, and sources of funding to implement the required infrastructure. Consensus recently has emerged that, due to the lack of recruitment of adolescent suckers into the adult spawning population, culturing and/or assisted rearing of larval suckers should be scaled up to prevent species extinction as work continues to reduce nutrient loading to the lake. Shared understanding of water quality conditions in the Klamath Basin among various stakeholders has been facilitated in recent years by the Klamath Basin Monitoring Program (KBMP), which coordinates basin-wide stakeholder meetings and serves a GIS-based interactive water-quality portal, featuring a metadatabase with 60 unique water-quality parameters collected at nearly 1,000 monitoring locations reported by 25 organizations throughout the Klamath.

KBMP is currently working to develop a time-series data visualization tool to improve access and comparison of data across sampling sites. We conclude with graphical examples of these tools and insights on their application to adaptive management and ecological restoration of the lake.

21. Nasim JANATIAN[1,2]

The temporal multiscalar response of phytoplankton on meteorological and hydrological forcing

[1]Chair of Hydrobiology and Fishery, Estonian University of Life Sciences, Tartu, Estonia
[2]Department of Evolutionary Biology, Ecology and Environmental Sciences, University of Barcelona, Barcelona, Spain

We aim to distinguish between hydro-meteorological forcing of lake phytoplankton community dynamics at different time scales from days to multiannual periods based on a 54-year mostly monthly phytoplankton database from a large shallow lake Võrtsjärv (Estonia-Mean depth 2.8m) combined with daily data on forcing factors – thermal, wind, and water level regimes.
For our analysis we use statistical methods which are categorized as follow:

- Nonmetric multidimensional scaling (NMDS) of Bray-Curtis similarity between phytoplankton samples.
- K-means clustering of NMDS scores for periodizing the changes.
- Variance Estimation and Precision (VEPAC) to analyze variance partitioning in variables among different time scales.
- Comparing of correlation results between phytoplankton and hydrometeorological variables with using general additive method (GAM model) and other statistical analysis.

We expect to see water level effects mostly at a decadal or annual scale, temperature effects at a seasonal scale and wind effects at a daily scale. At the same time, the relationships at the highest (daily) resolution should reveal the most direct effects whereas at lower resolution the relationships may be mediated by other factors, contain time lags etc.

22. Stephen F. JANE[1], Kevin C. Rose[1], and many other contributors

Long-term and broad-scale declines in dissolved oxygen observed in both epilimnetic and hypolimnetic waters across a globally-distributed suite of ~400 lakes

[1]Department of Biological Sciences, Rensselaer Polytechnic Institute, Troy, NY 12180, USA

Dissolved oxygen (DO) is a critical resource for many lake organisms. DO can be a limiting resource in lakes, especially in the hypolimnion, where hypoxia can limit habitat for some organisms. Cold water fish, for example, rely on the hypolimnion as a thermal refuge in many lakes during the summer and require well oxygenated water. DO responds to temperature through its effects on oxygen solubility, ecosystem respiration, and stratification duration and stability. Lake temperatures are currently increasing globally, and these changes are likely to impact DO levels. To better understand how DO is responding to these changes, we collected temperature and DO profiles from roughly 400 lakes around the world using the GLEON network and government agencies. Lakes had at least 15 years of data. We used Sens slope to analyze trends in individual lakes, combined with generalized additive mixed models (GAMM) to obtain an overall population level response. Epilimnetic DO decreased in 71% of lakes. 231 lakes (59%) had combined epilimnetic temperature increases and DO loss. Another 81 lakes (20%) had increasing epilimnetic temperatures combined with increasing DO concentrations. GAMM analysis demonstrated that when Secchi depths were below ~3m and epilimnetic temperatures exceeded ~23°C, epilimnetic DO increased dramatically. It is likely that increasing epilimnetic temperatures are resulting in reduced DO due to solubility in general but that in some productive lakes, increasing temperatures are driving increased algal biomass and blooms, resulting in increased epilimnetic DO. Our initial analysis also indicates an overall loss of DO from the hypolimnion.

23. Martin J. KAINZ[1], Robert Ptacnik[1], Serena Rasconi[1], Hannes H. Hager[1]

Irregular changes in lake surface water temperature and ice cover in subalpine Lake Lunz, Austria

[1]WasserCluster Lunz, 3293 Lunz am See, Austria; www.wcl.ac.at

Evidence is growing that the surface water temperature increases and the duration of ice cover
has decreased in many lakes worldwide during the past few decades. Here, we present changes in surface water temperature and ice-cover duration of Lake Lunz from 1921 to 2015 and evaluate how fast these changes occur over time, in particular with respect to other lakes with similar long-term data series. Since 1921, the surface water temperature of this Austrian subalpine lake has increased by 0.8 °C, with the most intense increase recorded during the spring and summer months (~1–2 °C) and less during fall (~0.3 °C). The duration of full lake ice cover has decreased significantly since 1921. During the 1921–2015 study period, Lake Lunz was ice covered for 92 of 94 winters, with ice-free winters in 2006 and 2013. The inter-annual decrease of the lake ice cover corresponds to 0.36 days less ice cover per year from 1921 to 2015. Freeze dates now occur 17.4 d/100 yr later, and the ice breakup date change is similar to the freeze date, 17.6 d/100 yr earlier. Although the duration of inter-annual ice cover varied by only 8.3 days between 1921 and 1930, on 32 days between 2006 and 2015 this inter-annual variability increased by almost 4 times. Thus, the observed decrease of ice cover is accompanied by increasing inter-annual variability, during which the lake was fully ice
covered. When comparing days of full ice cover to other lakes until 2005, Lake Lunz had a similar decline in ice-cover duration (1.85 d/decade), but a dramatic decrease in full ice cover during 2005 and 2015 indicates that the overall decline in lake ice-cover duration was sensitive to changes in lake ice cover during the past decade. This study emphasizes the importance of continuous and collaborative measurements in other (subalpine) lakes worldwide to test, and also manage, the sensitivity of lakes to ongoing effects of climate change.

24. Hares KHAN[1,2], Rafael Marcé[3], Alo Laas[2,3], Biel Obrador[1]

Major effects of alkalinity on the relationship between metabolism and dissolved inorganic carbon dynamics in lakes

[1]Department of Evolutionary Biology, Ecology and Environmental Sciences, University of Barcelona, Spain,
[2]Estonian University of Life Sciences, Institute of Agricultural and Environmental Sciences, Centre for Limnology, Estonia,
[3]Catalan Institute for Water Research, ICRA, Spain

Several findings suggest that dissolved inorganic carbon (DIC) dynamics and carbon dioxide (CO_2) emissions in lakes are not always directly linked to changes in metabolic rates but can be associated to exogenous DIC inputs from the watershed, as well as interactions with the dissolved inorganic carbon equilibria. Alkalinity has been described as a determining factor in regulating the relative contributions of biological and inorganic processes to carbon dynamics in lakes. Here we analyze the relationship between the net ecosystem production (NEP) and DIC at different time scales in several lakes of contrasting alkalinity and trophic state. We use high frequency data from state-of-the-art automatic monitoring stations to explore the sensitivity of DIC to changes in oxygen and the effects of seasonal variations and episodic events (such as storms) on the NEP-DIC relationship. Results suggest that in most of our studied lakes, a large part of the measured variability in dissolved oxygen and DIC reflects non-metabolic processes. Furthermore, at low alkalinity, DIC dynamics appear to be mostly driven by aquatic metabolism, but this relationship weakens with increasing alkalinity. Direct external DIC inputs, as well as calcite precipitation are likely the main processes at cause.

25. Samiullah KHAN[1], Carolyn Burns[1], Susie Wood[2], Marc Schallenberg[1]

Lake sediment as sentinels of historical food web dynamics: A case study of two eutrophic lakes in Central Otago, New Zealand

[1]Department of Zoology, University of Otago, Dunedin, New Zealand
[2]Cawthron Institute, Nelson, New Zealand

Paleolimnological studies are increasingly recognized as a means to re-construct historical food web structure and ecosystem dynamics. *Daphnia* plays a central role in many pelagic food webs, and has the potential to be used as an indicator of health and resilience of lake ecosystems. We studied two eutrophic lakes, Lake Hayes and Lake Johnson in Central Otago, New Zealand and investigated several paleolimnological parameters with special emphasis on *Daphnia* dynamics. We assessed the historical dynamics of two *Daphnia* species and compared our palaeolimnological reconstructions with known historical changes to the lake food web (e.g., trout and perch introductions, partial adult perch removal) and to the known historical progress of eutrophication in the lakes. Sediment cores were collected, and *Daphnia* subfossil remains (post-abdominal claw, resting eggs (ephippia)) in sequential slices from increasing depths from the surface of the core, were examined. Claws and ephippia were counted and taxonomically identified morphologically to infer historical relative abundance of the *Daphnia* species. This information was used to construct a timeline of *Daphnia* species invasion, co-existence and possible exclusion. To improve taxonomic resolution and verify fossil-based taxonomy, molecular analysis (DNA) was conducted on embryos from viable ephippia. A ^{210}Pb chronology was conducted to determine approximate time of sediments deposition. Stable nitrogen (δ15N) and carbon (δ13C) isotopes were analyzed to track historical changes in trophic composition and assess changes in the relative contribution of different sources of organic matter to the lake over time. Results reveal that *Daphnia 'pulex'* from North America became established in Lake Hayes during the 1960s, four decades earlier than first reported in Lake Hayes, while in Lake Johnson it became established during the 1980s. Results also suggest that indigenous *D. thomsoni* and non-indigenous *D. 'pulex'* co-exist in both lakes and demonstrate a consistent increase in *D. 'pulex'* abundance since this species first became established, with sporadic fluctuation in overall *Daphnia* abundance. There was no consistent pattern in *Daphnia* historical abundance associated with changes in lake primary productivity. Ephippia counts suggest that few years after *D.'pulex'* became established, the number of resting eggs produced by *D.thomsoni* doubled followed by 80-fold increase in ephippia of *D.'pulex'*. However, number of ephippia were not consistent with relative abundance of both species. The prolonged co-existence is an affirmation of a previous study that suggests these two species prefer different temperature regimes and therefore their realized niches for planktonic existence within a fundamental niche are temporally divided. We conclude that for development of lake management and restoration plans, paleo-assessment can be a strong tool particularly to evaluate implication of potential biomanipulation techniques.

26. T. LANGENEGGER[1], D. Vachon[1,2], D. Donis[1], C. Ordonez[1], T. DelSontro[1], D. F. McGinnis[1]

Seasonal gas dynamics of an anoxic eutrophic lake

[1]Department F.-A. Forel for Environmental and Aquatic Sciences (DEFSE), Faculty of Science, University of Geneva, Switzerland
[2] now at Department of Ecology and Environmental Sciences, Umeå Universitet, Sweden

Methane (CH_4) is of ongoing concern as a potent greenhouse gas. In lakes, CH_4 is produced in anoxic sediments. Estimates of total global emissions to the atmosphere, however, remain highly uncertain. Eutrophic lakes have especially high emission rates. During fall turnover, these emissions can be related to anoxic CH_4 rich bottom waters, accompanied by exacerbated oxygen depletion from aerobic CH_4 oxidation (Vachon et al., submitted). Besides emissions, CH_4 plays a role in the carbon budget (diminished C burial, re-supply of C to the food web). In earlier work (Langenegger et al., submitted) we showed that at the sediment level that production, diffusion, ebullition and concentration are inter-related. Here we integrated mechanistic understanding of crucial sediment processes into a 1D lake model. The model finally couples sediment processes with a water column bubble model, hydro- and thermodynamics, primary production as well as dissolved gasses (O_2, CO_2, CH_4, N_2, Ar). We have monitored the small eutrophic lake Soppensee (CH) over more than two years and thus obtained an extensive data set on hydro- and thermodynamics and water dissolved gas concentrations (O_2, CO_2, CH_4), sediment CH_4 production, ebullition and diffusion rates. We can thus calibrate and validate parameters governing the all-year temporal gas dynamics, incl. fall turn over. This allows us to investigate the triangular feedback effects between CH_4 ebullition, eutrophication and climate change. The results will help to evaluate CH_4 emission mitigation strategies and lake responses to future climate change scenarios.

27. Junjie LIU[1,2], Carolyn E. Oldham[2], and Matthew R. Hipsey[3]

Temporal metabolism responses to different hydrological regimes in constructed wetlands

[1]State Key Laboratory of Water Resources & Hydropower Engineering Science, Wuhan University, Wuhan 430072, PR China.
[2]School of Engineering, University of Western Australia, Perth, WA, Australia
[3]Aquatic Ecodynamics, UWA School of Agriculture and Environment, University of Western Australia, Perth, WA, Australia

Constructed wetlands (CWs) are a recognized popular method to mitigate non-point source pollution. The occurrence of non-point source pollution usually accompanies runoff during storm events, which is a particular concern in urban environments. In this circumstance, CWs are subject to a variable hydrological regime and transition periodically between lentic and lotic systems. Thus, the mechanisms for removing pollutants are time-dependent and affected dramatically by weather. Specifically, the response of wetland metabolism to flow is an interesting area to understand the performance of CWs to transform incoming nutrients. This research employed a three-dimensional hydrodynamic model coupled with aquatic model (TUFLOW-FV–AED2) to reproduce diel-scale oxygen dynamics throughout one CW for two months, over a period where three storms occurred. High –resolution dissolved oxygen (DO) at the inlet and within the CW was used for input and calibration of the model, respectively. Each component contributing to oxygen metabolism was calculated in the model, including inflow of oxygen, outflow of oxygen, atmospheric flux, photosynthesis, respiration and sediment oxygen demand. The model performed well in reproducing the highly-variable diel oxygen signal. During the storm period, oxygen within CWs were under control of inflow of oxygen, and limited metabolism occurred due to short residence time. On the contrary, after the storm event, the concentration of DO showed a strong diurnal change. This can be explained by the increase in the photosynthesis. During the daytime, DO shows stratification on account of solar radiation. While at night, the cooling of water give rise to the disappearance of stratification of DO. It is envisaged the model can assist in the design of CWs to maximise nutrient assimilation.

28. Mary E. LOFTON[1], Taylor H. Leach[3], Beatrix E. Beisner[2], and Cayelan C. Carey[1]

Seasonal variation in thermal stratification affects phytoplankton community structure and vertical distribution in north temperate lakes

[1]Department of Biological Sciences, Virginia Tech, Blacksburg, VA, USA
[2]Department of Biological Sciences, Rensselaer Polytechnic Institute, Troy, NY, USA
[3]Department of Biological Sciences, University of Québec at Montreal, Montreal, QC, Canada

Water column thermal structure is a key driver of phytoplankton community structure in lakes, as stratification strength can determine rates of sinking loss and the accessibility of nutrients to phytoplankton. However, it is unknown whether there are predictable effects of seasonal variation in thermal stratification on the vertical distribution of major phytoplankton groups. This knowledge gap is partly because traditional methods of measuring phytoplankton, such as microscopic counts or chlorophyll-a fluorescence, make it labor-intensive to assess finely-resolved depth distributions of phytoplankton groups across many lakes. We collected fluorescence-based depth profiles of four phytoplankton spectral groups, temperature profiles, and photic zone phytoplankton counts in early (June), mid (July), and late (September) thermal stratification periods from 18 lakes in Québec, Canada. We calculated a suite of thermal stability and phytoplankton community metrics, including several depth-related metrics such as the coefficient of variation of spectral group biomass across the photic zone, and used linear models to assess relationships between stratification strength and phytoplankton community structure. Preliminary results suggest that increased stratification strength increases variability in the vertical distribution of phytoplankton biomass. Furthermore, our data suggest that the degree of thermal stratification influences the depth at which spectral groups are found and the degree to which different groups co-exist in the water column. Our results, which are robust across a group of lakes varying in maximum depth, water chemistry, and light environment, provide predictions for how phytoplankton might respond as warming climates lead to changes in stratification strength in lakes worldwide.

29. *Jorrit MESMAN[1], Ana Ayala[2], Marieke Frassl[3], Rita Adrian[4], Mikkel Andersen[5], Elvira de Eyto[6], Gosia Golub[2], Stéphane Goyette[7], Eleanor Jennings[5], Ian Jones[8], Jérôme Kasparian[7], Tadhg Moore[5], Marjorie Perroud[9], Don Pierson[2], Harriet Wilson[5], and Bastiaan Ibelings[1]*

Model comparison study on the effects of extreme events on lake thermal structure

[1]Department F.-A Forel for Environmental and Aquatic Sciences & Institute for Environmental Sciences, University of Geneva, Geneva, Switzerland
[2]Department of Ecology and Genetics, Uppsala University, Uppsala, Sweden
[3]Australian Rivers Institute, Griffith University, Nathan, Australia
[4]IGB Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany
[5]Department of Applied Sciences, Dundalk Institute of Technology, Dundalk, Ireland
[6]Marine Institute, Newport, Ireland
[7]Group of Applied Physics & Institute for Environmental Sciences, University of Geneva, Geneva, Switzerland
[8]Centre for Ecology and Hydrology, Lancaster, United Kingdom
[9]Climate Change Impacts and Risks in the Anthropocene, Institute for Environmental Sciences, University of Geneva, Geneva, Switzerland

Recently, limnologists have paid increased attention to extreme climatic events (ECEs), which are expected to become more frequent and intense with climate change. ECEs in the atmosphere (e.g. storms and heatwaves) have a direct effect on lake physics, which is again a determinant for chemistry and biology, especially in stratified lakes. So far, numerical lake modelling has not yet focused much on how accurately lake physics are simulated during ECEs. Instead, model calibration and validation often focused on a measure for goodness-of-fit of main variables over a long period, although the long timescale obscures any misfits during particular extreme events. The availability of long time series with high-frequency data now makes it possible to have a closer look at model results and observed lake thermal structure specifically before and after ECEs.
The main objective of this study is to compare the ability of three different 1D hydrodynamic models to simulate impacts of aforementioned extreme events (we focus on storms and heatwaves) on the vertical thermal structure of three different lakes. At least 10 years of high-frequency data from three lakes with different mixing regimes are used: Lake Erken (Sweden), Lough Feeagh (Ireland), and Müggelsee (Germany). The 10 most severe events in each lake have been selected, based on wind speed and temperature. The goodness of fit of the GLM, GOTM, and SIMSTRAT models is assessed and compared with each other. The assessment is performed over the whole validation period, but also in more details during and after the selected extreme weather events.

30. Chenxi MI[1], Valerie C. Wentzky[1], Bertram Boehrer[1], Karsten Rinke[1]

Simulating *Planktothrix rubescens* bloom and metalimnetic oxygen minimum: A case study for Rappbode Reservoir

[1]Helmholtz Centre for Environmental Research, Department of Lake Research, Magdeburg, Germany

Although the forming of metalimnetic oxygen minimum (MOM) in aquatic systems during summer stratification was described by early limnologists, very few studies were reported to accurately capture the phenomenon by using modeling tools. To fill in the gap, in this study, a two-dimensional physical–biological coupled model (CE-QUAL-W2) was used to simulate hydrodynamic and water quality in Rappbode Reservoir (eastern Germany), in which a reoccurring metalimnetic oxygen minimum was observed during late summer. The results showed that our calibrated model accurately captured the water temperature, nutrients (Nitrate, Orthophosphate, Silicon), algae groups (Diatom, Planktothrix rubescens) and well reproduced the occurrence of MOM. By analyzing the scenario results, the study further illustrates the decisive impact of decomposition of dead planktothrix rubescens on the forming of MOM, which confirms our previous research.

Keywords: Rappbode Reservoir/ metalimnetic oxygen minimum / Planktothrix rubescens/ CE-QUAL-W2/ decomposition

31. Karen E.B. MOORE[1] and Alfred Theodore N.K. Kpodonu[1,2]

A Tale of Two Watersheds: Assessing Sources of Organic Matter and Disinfection By-Product Precursors

[1]New York City Department of Environmental Protection, Kingston, New York, USA
[2]City University of New York, New York, New York, USA

Undesirable disinfection by-products (DBPs) form when natural organic matter in drinking water is disinfected with chlorine. Although only a fraction of the organic matter pool forms DBPs, a study of DBP precursors in two watersheds in the New York City (NYC) water supply is underway to inform water management. Beyond data on DBP formation potential (DBPfp), other proxy measurements from the field and laboratory are being used to characterize sources of natural organic matter. Study sites include Cannonsville and Neversink Reservoirs and their associated watersheds to represent different system characteristics. Cannonsville is the most eutrophic reservoir and Neversink is the most oligotrophic reservoir in the West of Hudson (WOH) system. We employ multiple strategies to collect relevant data, including fixed-frequency sampling at reservoir and stream sites, storm event sampling at stream sites, and high frequency monitoring at reservoir buoys and stream stations using optical sensors. Analytes include temperature, conductivity, turbidity, chlorophyll and phycocyanin fluorescence, fluorescent dissolved organic matter (fDOM), absorbance at 254 nm (UV_{254}), dissolved organic carbon (DOC), and DBPfp. We explore relationships to identify surrogates for evaluating DBPfp with the ultimate goal of developing a predictive model to assist in making operational decisions to minimize the presence of DBPs in the NYC water supply.

32. Tadhg N. MOORE[1], Karsten Bolding[2], Jorn Bruggeman[2], Raoul-Marie Couture[3], Mary Dillane[4], Moshe Estroti[5], Elvira de Eyto[4], Gideon Gal[5], Jose-Luis Guerrero[3], Eric Jeppesen[6], Anders Nielsen[6], Don Pierson[7], Denis Trolle[6] and Eleanor Jennings[1]

Modelling in-lake DOC events using a newly developed DOC model coupled with a 1-D hydrodynamic model

[1]Centre for Freshwater and Environmental Studies, Dundalk Institute of Technology, Dundalk, Co. Louth, Ireland
[2]Bolding & Bruggeman ApS
[3]NIVA, Oslo, Norway
[4]Marine Institute, Newport, Co. Mayo, Ireland
[5]Kinneret Limnological Laboratory, Kinneret, Israel
[6]Aarhus University, Silkeborg, Denmark
[7]Uppsala University, Uppsala, Sweden

The PROGNOS project is developing a modelling framework which will combine 1-D hydrodynamic models with biogeochemical model to provide 7-day water quality forecasts for lakes and reservoirs. The focus is on predicting algal blooms and dissolved organic carbon (DOC) fluxes within the lake. Here, we report on a newly developed in-lake DOC model, DOMCAST, which is being used to predict changes in DOC levels on short temporal scales in a humic lake in the west of Ireland, Lough Feeagh. A catchment model, INCA-C, has been set up for the catchment and is being used to predict inflows and inflow concentrations of DOC which, in combination with local climate data, will be used to force the model. Measured water temperature and CDOM fluorescence from the lake will be used to calibrate the model. These measurements will also be used to assess the model's ability to predict the changes in DOC. We aim to include estimates of uncertainty at each step, to help further communicate the possible range in errors from the model. It was found that the model captured DOC dynamics within the lake when forced with measured data showing that the DOMCAST model can accurately simulate in-lake DOC concentrations.

33. Hamid NOROUZI[1], Abdou Bah[1], Cho May Than[2], Patty Arunyavikul[1], Ronaldo Carhuaricra[1], and Reginald Blake[1].

Analysis of driving factors of global lakes surface temperature

[1]New York City College of Technology - 300 Jay St, Brooklyn, NY 11201
[2]LaGuardia Community College -31-10 Thomson Ave, Long Island City, NY 11101

Lakes are among vital components of our ecosystem and environment that are crucial for supplying fresh water, recreation, habitat's lives and etc. Dying Lakes are one of the climate change phenomena that are some due to the human mismanagement, pollution, and loss. The variations in Land Surface Temperature (LST) of lakes could be one indicator of these changes, especially in the world's dying Lakes. This project focuses on the application of remote sensing and geographic information system for change in land cover, and analysis on its impact on the surface temperature trends of the 300 major lakes around the world. The objective of this study is study the differences between the changes of syrface temperature of water and their surrounding land to understand underlying factors of lake area changes. An analysis of LST variation over the global lakes have been conducted using observations from the Moderate Resolution Imaging Spectroradiometer (MODIS). A statistical approach was applied to calculate the temperature trends in the lake (water), surrounding land, and the difference between land and water. Moreover, the relationships between the LST trends and potential driving factors such as the landcover changes in the lakes' basins, lakes areas, depth, and location were investigated. The results show that there is a direct relationship between changes in the lakes area and the trends in the lake temperature and the surrounding land temperature. Lakes with smaller surface areas showed more significant changes in LST when compared with larger lakes.

34. Rachel M. PILLA[1], Craig E. Williamson[1], and many others

Global Temperature Sentinels (Climate Sentinels Working Group): Global trends in lake thermal structure and underlying patterns

[1]Department of Biology, Miami University, Oxford, Ohio, USA

Lake temperatures serve as a structural ecosystem driver that can affect the vertical distribution of oxygen, nutrients, and habitat availability, and are a valuable signal of environmental change. Changes in lake physical characteristics related to temperature can compromise the ecosystem function and services, including their value as drinking water sources. We have compiled the most complete database to date of long-term vertical temperature profiles in lakes across the world to understand changes in whole-lake thermal structure. The geographic span of the 100 lakes analyzed covers five continents and 18 countries, with lakes ranging widely in surface area, depth, latitude, elevation, transparency, and trophic status. At a global scale, the rates of change of lake temperature and stratification in lakes are highly variable. As expected, most lakes show epilimnion warming and increases in strength of stratification, with the most consistent trends in northeastern North America and northern Europe. Geographic trends in hypolimnion temperature are much more variable, and do not clearly mimic the trend found for epilimnion temperature within the same lake or region. Trends in hypolimnion temperature show high variation in both the direction and magnitude even in lakes that are very near to one another. Dynamic factor analyses for these metrics suggest that epilimnion temperature trends and stratification trends have an underlying increasing pattern. However, hypolimnion temperature trends exhibit one of two underlying patterns, one increasing and one decreasing. This suggests region- or lake-specific factors are influencing hypolimnion temperature, which can have important ecological consequences influencing the availability of oxygen and nutrients, and thus vertical habitat gradients for aquatic organisms.

35. Dale M. ROBERTSON[1], Benjamin Siebers[1], Paul C. Reneau[1], and Cory P. McDonald[2]

Understanding the Causes of Metalimnetic Hypoxia and Water-Quality Degradation in Big Green Lake, Wisconsin

[1]Upper Midwest Water Science Center, U.S. Geological Survey, Middleton, Wisconsin, USA.
[2]Dept. of Civil and Environmental Engineering, Michigan Technological University, Houghton, MI, USA.

Big Green Lake is the deepest natural lake in Wisconsin, USA; maximum depth of 72m. In the early 1900's, the lake was oligotrophic, with hypoxia only occurring in the deepest part of the hypolimnion. In recent years, however, it is believed that increased nutrient loading from its agricultural and urban watershed has caused the lake to become mesotrophic, with hypoxia occurring in both the metalimnion and deeper parts of the hypolimnion. Comprehensive sampling of the lake and its tributaries was conducted during 2017–18 to describe the present water quality and planktonic community in the lake and tributary loading of nutrients, organic carbon, and biological oxygen demand to the lake. In addition, continuous temperature and dissolved oxygen were recorded at various depths using buoys placed at both ends of the lake to characterize metalimnetic oxygen dynamics over various temporal scales. To describe spatial variability in water quality in the lake, a sonde with fast responding sensors was towed in an undulating pattern through the lake during summer stratification. The Aquatic Ecodynamics (AED) modeling library coupled to the General Lake Model (GLM) is currently being used to describe the short-term changes in the hydrodynamics and water quality in the lake and to understand the factors causing the degradation in water quality and the associated increase in the metalimnetic oxygen minimum (MOM) and deeper hypolimnetic hypoxia. The goal of the study is to provide information to guide watershed efforts to improve the water quality of the lake and reduce the MOM.

36. Amina SAEED[1,4] , Peisheng Huang[1,2], Kerry Trayler[3] , Carolyn Oldham[2,4], Benya Wang[4] and Matthew R. Hipsey[1,2]

Integration of routine and high-frequency data to improve 3-D water quality model predictions

[1] Aquatic Ecodynamics, UWA School of Agriculture and Environment, The University of Western Australia, Crawley WA 6009, Australia.
[2] UWA Oceans Institute, The University of Western Australia, Crawley WA 6009, Australia.
[3] Rivers and Estuaries Division, Department of Biodiversity Conservation and Attractions, Kensington WA 6151, Australia.
[4] School of Engineering, The University of Western Australia, Crawley WA 6009, Australia.

The challenges of supporting short- and long-term water quality management decisions in aquatic systems require a holistic view of their internal response to external stressors. Whilst regular monitoring programs of water quality with weekly or longer time intervals allows for tracking trends in water quality and an understanding of the system evolution over extended periods of time, high frequency monitoring data offers potential to improve our knowledge of the finer-scale hydrodynamic and biogeochemical processes (e.g. mixing, diel metabolism). Such data also offers great potential to assist in the calibration and testing of water quality models targeting hypoxia and harmful algal bloom issues, but as yet their remains challenges in the uptake of sensor data into model prediction workflows. Here we report an approach to the integration of models and observations for the Swan-Canning system, a eutrophic urban estuary in Western Australia, under threat from nutrient enrichment and changing hydrology. Initially, modelling to facilitate hypoxia management and nutrient budgeting was supported by a long-term monitoring strategy, which together highlighted changes brought about by a notable drying climate trend. A real-time water quality system, SCEVO (Swan-Canning Estuary Virtual Observatory), was subsequently developed to support decision-making and streamline prediction workflows. The real-time system uses the validated 3D finite volume water quality model (TUFLOW-FV–AED2), and integrates a data management system, weather model (WRF), and a coastal model (ROMS), to generate a hindcast and a daily 5-day forecast of water quality conditions online. A conceptual framework is outlined for how sensor data is able to be used for supporting the model predictions. First, due to the often patchy and time-lagged nature of nutrient monitoring, the application of machine-learning methods has been introduced to exploit available sensor data for prediction of boundary condition inputs (e.g. inflowing nutrient loads) required to run the model. Secondly, high-frequency oxygen data is being used to identify local drivers of productivity, which is assisting in how the model configuration captures the diel-scale sensitivity of metabolism to light, flow and benthic activity. Looking forward, an *in situ* sensor platform is under development in the centre of the Swan River that will report high-frequency changes in key water quality parameters including chl-a, salinity, oxygen, temperature, PAR, fDOM and pCO2. It is envisaged that the new data streams will support further connections between data-driven and process-based model approaches, and ultimately lead to more “process—inspired” calibration opportunities of the model system.

37. Adrianne P. Smits[1] and Steve SADRO[1]

Multiple mechanisms dictate lake thermal responses to changing snowpacks in mountain regions

[1]Department of Environmental Science and Policy, University of California, Davis, CA, USA

Global and regional analyses of lake temperature show highly variable thermal responses despite overall warming trends in air temperature. In many mountain regions, variation in summer lake temperatures is strongly associated with snow cover and snowmelt inputs, which generally vary with elevation. However, lake and catchment features should mediate the influence of snow on lake thermal regimes. Understanding mechanisms by which snowpack influences lake temperature, and further how lake and catchment features interact with these mechanisms, will allow us to understand and predict variable lake responses to warming and snow-loss associated with climate change. We use three decades of data from a small sub-alpine lake in the Sierra Nevada to illustrate the role of snow on lake temperature, and model lake heat budgets in three years that span an order of magnitude in snowpack to characterize mechanistic controls on lake temperature, warming rates, and water column stability. We apply this mechanistic perspective to a regional-scale analysis of thermal regimes in lakes across the Sierra Nevada in order to develop a formal framework for understanding how environmental gradients and mosaic features dictate lake responses to climate change.

38. L. SENERPONT DOMIS[1], M. Beklioğlu[2], S. Berger[3] and J. Nejsgaard[3]

AQUACOSM: Connecting freshwater and marine ecosystem-scale mesocosm approaches to ecosystem-scale questions

[1]Netherland Institute of Ecology (NIOO), Wagenningen, The Netherlands;
[2] Middle East Technical University, Limnology Laboratory, Ankara, Turkey;
[3] Leibniz-Institute of Freshwater Ecology and Inland Fisheries, IGB, Berlin, Germany

To obtain mechanistic quantitative understanding of aquatic ecosystem functioning and biogeochemical processes, a range of empirical approaches have been used from laboratory to ecosystem scale, such as mesocosms. It is becoming increasingly clear that mesocosm experiments is a powerful approach to obtain such mechanistic quantitative understanding, especially when embedded in long-term observations, theoretical models and experiments conducted at other scales. However, after decades of ecosystem-scale empirical studies, there is still little standardization and collaboration across sites and biomes, especially between freshwater and marine systems. To challenge these issues, the EU-INFRAIA project INFRAIA aims to coordinate research, develop common best practices and open both freshwater and marine large-scale research infrastructures (mesocosms) for international cross-discipline participation. In addition, AQUACOSM offers scientists, students, trainees, enterprises and others transnational access to 37 mesocosms facilities in Europe.

39. Ana C. SINGH[1], Dan Paraska[2], Matthew R. Hipsey[2], Carolyn Oldham[1]

Reactive transport modelling of iron fluxes in an acidic mine lake with groundwater inflow

[1]School of Engineering, University of Western Australia, Perth, WA, Australia
[2]Aquatic Ecodynamics, UWA School of Agriculture and Environment, University of Western Australia, Perth, WA, Australia

Water quality evolution in mine pit lakes is an important issue that affects permitting of new mines, expansion of existing ones and closure processes. Therefore, modelling the controls and drivers that impact the long-term evolution of water characteristics, is essential for predicting and addressing water quality concerns that may arise after cessation of mining activities. A major water quality problem in mine lakes is the acidification caused by the oxidation of sulfidic ores, in particular pyrite. However, proton consuming processes in sediments have been shown to promote the retention of iron and sulphate and affect the acidity budget. These processes rely on the shift from an iron regime to a sulfidic regime that is pH dependent and driven by groundwater dynamics particularly by the rate of alkalinity input. The complex interplay between reaction and transport processes are insufficiently understood and thus the system response to changes in groundwater inflow, the sustainability of the sulfidic regime and its impact on the evolution of the water acidity, remain uncertain. The aim of this research is to determine conditions under which iron fluxes are minimised and attenuation of acidity in the mine lake is improved. For this end, a numerical model AED-CANDI describing critical sediment processes involved in acidity consumption and generation will be set up and coupled with the General Lake Model (GLM) to explore feedbacks between the water column and sediment processes under different groundwater inflows, vertical mixing and oxygen regimes. Model results will be used to identify controls and thresholds on the lake processes and simulate the resultant impact on iron fluxes and water acidity under different scenarios.

40. *Jason D. STOCKWELL[1], Rita Adrian[2], Mikkel Andersen[3], Orlane Anneville[4], Ruchi Bhattacharya[5], Wilton G. Burns[6], Cayelan C. Carey[7], Laurence Carvalho[8], Chun-Wei Chang[9], Lisette N. De Senerpont Domis[10], Jonathan P. Doubek[1], Gaël Dur[11], Marieke A. Frassl[12], Mark O. Gessner[13], Josef Hejzlar[14], Bas W Ibelings[15], Nasim Janatian[16], Alfred T.N.K. Kpodonu[17], Marc J. Lajeunesse[18], Aleksandra M. Lewandowska[19], María E. Llames[20], Shin-ichiro S. Matsuzaki[21], Emily R. Nodine[22], Peeter Nõges[16], Ho-Dong Park[23], Vijay P. Patil[24], Francesco Pomati[25], Alon Rimmer[26], Karsten Rinke[27], Lars G. Rudstam[28], James A. Rusak[29], Nico Salmaso[30], François Schmitt[31], Christian T. Seltmann[3], Sami Souissi[32], Dietmar Straile[33], Stephen J. Thackeray[34], Wim Thiery[35, 36], Pablo Urrutia-Cordero[37], Patrick Venail[15], Piet Verburg[38], Tanner J. Williamson[39], Harriet L. Wilson[3], Tamar Zohary[26]*

Storm impacts on phytoplankton community dynamics in lakes

[1]University of Vermont, Rubenstein Ecosystem Science Laboratory, Burlington, Vermont, USA
[2]Leibniz Institute of Freshwater Ecology and Inland Fisheries, Department of Ecosystem Research, Berlin, Germany
[3]Centre for Freshwater and Environmental Studies, Dundalk Institute of Technology, Dundalk, Ireland
[4]Institut National de la Recherce Agronomique, 75 avenue de Corzent, Thonon-les-Bains, France
[5]University of Missouri, Columbia, School of Natural Resources, 1105 Rollins Road, Columbia, Missouri, USA
[6]University of Vermont, Vermont EPSCoR, 334 Marsh Life Sciences, 109 Carrigan Drive, Burlington, Vermont, USA
[7]Virginia Tech, Biological Sciences, 926 W. Campus Drive, Blacksburg, Virginia, USA
[8]Centre for Ecology & Hydrology, Freshwater Restoration & Sustainability Group, Bush Estate, Penicuik, Midlothian, UK
[9]National Taiwan University, Institute of Oceanography, Taipei, Taiwan
[10]Netherlands Institute of Ecology, Aquatic Ecology, Droevendaalsesteeg 10, 6708 PB, Wageningen, Gelderland
[11]Shizuoka University, Creative Science Unit (Geoscience), 836 Ohya, Surugaku, Shizuoka, Japan
[12]Griffith University, Australian Rivers Institute, 170 Kessels Road, Nathan, Queensland 4111, Australia
[13]Leibniz Institute of Freshwater Ecology and Inland Fisheries, Department of Experimental Limnology, Stechlin, Germany
[14]Biology Centre of the Czech Academy of Sciences, Institute of Hydrobiology, Na Sádkách 7, 370 05 České Budějovice, Czechia
[15]Department F.-A. Forel for Environmental and Aquatic Sciences, Institute for Environmental Sciences, University of Geneva, Geneva, Switzerland
[16]Estonian University of Life Sciences, Institute of Agricultural and Environmental Sciences, Fr.R. Kreutzwaldi 5, 51006 Tartu, Estonia
[17]Research Foundation, City University of New York, New York, New York , USA
[18]Department of Integrative Biology, University of South Florida, Tampa, Florida, USA

[19]Tvarminne Zoological Station, University of Helsinki, J.A. Palmenin tie 260, Hanko, Finland
[20]Laboratorio de Ecología y Fotobiología Acuática; IIB-INTECH (UNSAM-CONICET), Av. Intendente Marino Km 8.2, Chascomus, Buenos Aires, Argentina
[21]National Institute for Environmental Studies, Center for Environmental Biology & Ecosystem Studies, Onogawa 16-2, Tsukuba, Ibaraki 305-8506, Japan
[22]Rollins College, Environmental Studies, 1000 Holt Avenue, Winter Park, Florida, USA
[23]Shinshu University, Environmental Science, 3-1-1 Asahi, Matsumoto, Nagano 309-8621, Japan
[24]US Geological Survey, Alaska Science Center, 4210 University Drive, Anchorage, Alaska, USA
[25]Eawag, Swiss Federal Institute of Water Science and Technology, Aquatic Ecology, Uberlandstrasse 133, Dubendorf, 8600, Switzerland
[26]Israel Oceanographic & Limnological Research, Kinneret Limnological Laboratory, Migdal, Israel
[27]Helmholtz-Centre for Environmental Research, Lake Research, Brückstrasse 3a, Magdeburg, Germany
[28]Cornell University, Natural Resources, Fernow Hall, Ithaca, New York
[29]Dorset Environmental Science Centre, Ontario Ministry of the Environment and Climate Change, Dorset, Ontario, Canada
[30] Research and Innovation Centre - Fondazione Mach (FEM), Via E. Mach, 1 - 38010, S. Michele all'Adige, Italy
[31]Laboratoire d'Océanologie et de Géosciences, 28 avenue Foch, BP 80, Wimereux, France
[32]Université de Lille, UFR Sciences de la Terre, 59655 Villeneuve d'Ascq, France
[33]University of Konstanz, Department of Biology, Limnological Institute, Mainaustr. 252, Konstanz, Germany
[34]Centre for Ecology & Hydrology, Lake Ecosystems Group, Lancaster Environment Centre, Library Avenue, Bailrigg, Lancaster, UK
[35]ETH Zurich, Institute for Atmospheric and Climate Science, Universitaetstrasse 16, Zürich, Zwitserland
[36]Vrije Universiteit Brussel, Department of Hydrology and Hydraulic Engineering, Pleinlaan 2, Brussels, Belgium
[37]Uppsala University; Department of Ecology and Genetics; Limnology, Evolutionary Biology Center; Kåbovägen 4; Uppsala, Sweden
[38]National Institute of Water and Atmospheric Research, Gate 10, Silverdale Road, Hamilton, New Zealand
[39]Miami University, Department of Biology, Oxford, Ohio, USA

In many regions across the globe, extreme weather events, such as storms, have increased in frequency, intensity and duration. Ecological theory predicts that such extreme events should have large impacts on ecosystem structure and function. For lake ecosystems, high winds and rainfall associated with storms are linked by short term run-off events from catchments and physical mixing of the water column. Although we have a well-developed understanding of how such wind and precipitation events alter lake physical processes, our mechanistic understanding of how these short-term disturbances

translate from physical forcing to changes in phytoplankton communities is poor. Here, we provide a conceptual model that identifies how key storm features (i.e., the frequency, intensity, and duration of wind and precipitation) interact with attributes of lakes and their watersheds to generate changes in a lake's physical and chemical environment and subsequently phytoplankton community structure and dynamics. We summarize the current understanding of storm-phytoplankton dynamics, identify knowledge gaps with a systematic review of the literature, and suggest future research directions by generating testable hypotheses across a global gradient of lake types and environmental conditions.

41. *Cleo N. STRATMANN[1,2,6], Lisette de Senerpont Domis[1,2], Harm van der Geest[3], Annelies Veraart[4,5], Maira Mucci[2], Kristof Brenzinger[5], Rafael Marcé[6] and Mike Lürling[1,2]*

Effects of extreme heatwaves on restored versus non-restored systems. – Results from a sediment core incubation experiment

[1]Netherlands Institute of Ecology, Department of Aquatic Ecology,
[2]Wageningen University and Research, Department of Aquatic Ecology and Water Quality management Group
[3]University of Amsterdam, Department of Aquatic Environmental Ecology
[4]University of Nijmegen, Department Aquatic Ecology and Environmental Biology
[5]Netherlands Institute of Ecology, Department of Microbial Ecology
[6]Catalan Institute of Water Research, Department of Resources and Ecosystems and Department of Water Quality

Extreme climatic events, such as heatwaves, can impair provision of ecosystem functions and services of aquatic systems. Oligotrophic freshwaters are suggested to be more resilient to impacts of extreme events than meso- or eutrophic freshwaters. To maintain sustainable freshwater resources, measures to increase resilience and control eutrophication are urgently needed. Geoengineering restoration techniques to strip phosphorus (P) from the water column and block sediment P release are widely used to re-oligotrophy freshwaters. However, there is a knowledge gap on what consequences extreme climatic events may have for this type of restoration measure in future climates. Are measures still applicable and do they increase resilience of the ecosystem?

To test the potential impact of extreme heatwaves on sediment P release in restored versus non-restored systems, sediment cores were incubated and exposed to different geoengineering techniques and temperatures over a period of three weeks. Concentrations of nutrients and metals in the water column were determined to see the effect of heatwaves on internal P loading and the efficiency of P adsorption. To further test if and how restoration measures impact the microbial community and related GHG emissions, dissolved gases (CO_2, CH_4, N_2O) were measured, redox-potential in the sediment water interphase was monitored at high-frequency and sediment layers will be analyzed for microbial community composition.

This experiment will give insights in whether or non-restored freshwaters are more resilient to extreme heatwaves. Results will further contribute to understanding ecosystem functioning in restored systems to maintain the provision of ecosystem services in future climate systems.

42. Ena L. SUAREZ[1], Bastiaan W. Ibelings[1]

Fine scale spatial and seasonal variation of the deep chlorophyll maximum (DCM) of Planktothrix rubescens in Lake Zurich, Switzerland.

[1]Department F.-A Forel for environmental and aquatic sciences, University of Geneva, Switzerland

Understanding the processes that govern the diversity of biological communities has always been a fundamental challenge in ecology and even more nowadays in light of anthropogenic impacts on biodiversity and ecosystem services. Here we focus on the broad scale seasonal and fine scale spatial variation of the deep chlorophyll maximum (DCM) of *Planktothrix rubescens* in Lake Zurich, Switzerland. We study how *Planktothrix* diversity varies with different physical and chemical vertical gradients within the DCM and between seasons. We formulate three main hypotheses on diversity changes that we expect along the vertical gradient of the water column: I) the size of the light harvesting antenna is larger for strains positioned at the bottom of the *Planktothrix* bloom. II) The degree of gas vacuolation is higher for strains positioned at the bottom of the *Planktothrix* layer. III) The number of toxigenic microcystin cells in the *Planktothrix* layer decreases with depth. To assess these hypotheses we had three field campaigns in spring, summer and fall of 2018. We used a fine scale sampler to collect simultaneously water samples every 0.1 m at the center of the DCM and an autonomous underwater vehicle (SNF SINERGIA project) to record 3-D data of the physical structure of the lake. The campaign results will allow us to explore the spatial differentiation and organization of *Planktothrix* functional diversity (filament dimensions, pigment content, degree of gas-vacuolation, toxicity), and answer the fundamental ecological question on how the seasonal variation of the physical and chemical environment allows different *Planktothrix* functional groups to grow and coexist.

43. Ryan VOGWILL[1]

Managing threats to the microbialites of Rottnest Island

[1]Director & Principal Hydrogeologist, HydroGeoEnviro PTY LTD
ryanv@hydrogeoenviro.com.au

The South West of Western Australia (SWWA) is recognised as one of the worlds "Biodiversity Hotspots" due to not only the high levels of biodiversity but also the high degree of threat from anthropogenic activities. Excellent examples of this biodiversity are microbialites of SWWA. Microbialites are produced by diverse microbial mat communities which typically biomediate $CaCO_3$ precipitation. They occur in coastal freshwater to hypersaline lakes as well as in groundwater springs. Each community typically has a different distinctive morphology and are often visually spectacular.

The large number of communities occurring in such close proximity, within one of the world's most ancient landscapes is no coincidence. The relative stability and ancient origins of the Australian continent would make this a logical site for modern analogues of these ancient communities to persist. These communities are the modern evolution of some of the first life forms to occur on the planet. They result from the interaction between the hydrosphere, biosphere and lithosphere which has been occurring in some form for more than 3.5 billion years.

Many communities are threatened by anthropogenic impacts and are highly sensitive bio-indicators. Research is needed to help us understand their origins, their links to local and regional hydrological regimes and their tolerances to altered hydrology, to ensure they are protected from existing and future threats. This presentation will focus on exploring the management of these issues using Rottnest Island lakes as an example.

44. *Heather L. WANDER[1], Emily Carter[2], Adrienne Tracy[2], Taro Katayama[2], Sabrina Volponi[3], Kiyoko Yokota[4], Shelley Arnott[5], Holly Ewing[6], Beth Norman[7], Mindy A. Morales[8], Clayton J. Williams[8], Nicole Ward[9], Jennifer A. Brentrup[9], Courtney R. Wigdahl-Perry[10], Kristen T. Holeck[11], Denise A. Bruesewitz[2], David C. Richardson[1]*

Inorganic nitrogen, organic nitrogen, and phosphorus limitation of lake phytoplankton and heterotrophs across northeastern North America

[1]State University of New York at New Paltz
[2]Colby College, Environmental Studies Program
[3]Bridgewater College
[4]State University of New York at Oneonta
[5]Queen's University
[6]Bates College
[7]Lacawac Sanctuary
[8]University of Vermont
[9]Dartmouth, Virginia Tech, Lake Sunapee Protective Association
[10]SUNY Fredonia
[11]Cornell University

Algal blooms have been increasing in both frequency and intensity in many aquatic systems as a result of the global increase in nutrient loading. Many studies have highlighted the differences between nitrogen and phosphorus in limiting freshwater phytoplankton; however far fewer have documented limitation based on the species of nitrogen. Additionally, autotrophic and heterotrophic use of nitrogen may differ depending on the concentration of organic and inorganic species present in a lake. We hypothesize that there will be different nutrient limitation types across a wide range of regional lakes and that heterotrophic and autotrophic responses will differ depending on the species of nitrogen added to lake microbial communities. To test these hypotheses, we performed factorial design for 28 northeastern North American lakes within the NE GLEON regional network using in-situ mesocosm experiments. For each lake, mesocosms received one of eight different treatments with possible amendments including phosphorus, inorganic nitrogen, and organic nitrogen. Following one-week incubation, mesocosms were processed for chlorophyll *a* (as a proxy for phytoplankton biomass) and bacterial densities. We observed varying types of nutrient limitation across our study lakes including colimitation of both nitrogen and phosphorus. The type of nitrogen affected phytoplankton and bacterial communities differently given that autotrophs and heterotrophs have different preferences for nitrogen species.

45. Nicole K. WARD[1], Jennifer Brentrup[2], David C. Richardson[3], Kathleen C. Weathers[4], Cayelan C. Carey[1]

Linking spatially explicit lake metabolism to spatially heterogeneous external nutrient loading

[1]Department of Biological Sciences, Virginia Tech, Blacksburg, VA, USA
[2]Department of Biological Sciences, Dartmouth College, Hanover, NH, USA
[3]Biology Department, SUNY New Paltz, New Paltz, NY, USA
[4]Cary Institute of Ecosystem Studies, Millbrook, NY, USA

Oligotrophic lakes are being rapidly altered as a result of land-use and climate change. Maintaining oligotrophic lakes in their low-nutrient state into the future requires robust water quality indicators. Lake metabolism, the balance of photosynthesis and respiration, is a sensitive, integrated ecosystem metric of water quality that may indicate impending ecosystem shifts to a meso- or eutrophic state. Most metabolism studies have focused on one pelagic, deep site within a lake; consequently, little is known about how estimates of lake metabolism at near-shore sites relate to localized nutrient loads. In this study, we asked: 1) How do lake metabolism estimates at near-shore sites compare to a single deep-site estimate? and 2) What are the primary drivers of near-shore vs. deep-site lake metabolism? We addressed these questions in oligotrophic Lake Sunapee, New Hampshire (USA), a GLEON site that has 11 inflow tributaries which range in nutrient loads. We used high-frequency measurements of dissolved oxygen, temperature, and light sensors to estimate metabolism at three littoral sites adjacent to inflows, and one pelagic site. To compare the drivers of lake metabolism at littoral vs. pelagic sites, we used a suite of in-lake and inflow tributary variables. Preliminary data revealed the intermittent development of a shallow (3 m) thermocline at two littoral sites, but no shallow thermocline at the pelagic site. Linking spatially variable lake metabolism to heterogeneous nutrient loading will provide insight into how lakes integrate upland processes, and inform the deployment of high-frequency sensors in GLEON lakes.

46. Valerie WENTZKY[1], Christoph Jäger[2], Jörg Tittel[1], Karsten Rinke[1]

Functional trait dynamics in phytoplankton communities during oligotrophication

[1]Helmholtz Centre for Environmental Research – Department of Lake Research, Brückstraße 3a, 39114, Magdeburg, Germany
[2]Helmholtz Centre for Environmental Research – Department of Aquatic Ecosystem Analysis and Management, Brückstraße 3a, 39114, Magdeburg, Germany, Email: christoph.jaeger@ufz.de)

Understanding and explaining the local phytoplankton communities in the pelagic water column is a central goal in aquatic biology. The preferences of phytoplankton functional groups to seasonal and vertical variations in nutrients, light, temperature and grazers are well known and have been verbally described by the Plankton Ecology Group (PEG model by Sommer et al., 1986). Using a quantitative approach, our study investigates phytoplankton functional traits along environmental gradients. We took advantage of a 50-year long, vertically-resolved data-set from a German reservoir, which underwent a strong shift in trophic conditions in the nineties. This data-set allowed us to quantitatively analyze seasonal and vertical developments in phytoplankton traits (e.g. phosphate affinity, ability to fix nitrogen) and to compare these patterns during eutrophic and oligotrophic conditions. We found that seasonal trait developments in our data-set provide not only a quantitative description but also a functional template for trait-based succession patterns in temperate lake ecosystems. The seasonal succession of traits differed depending on trophic status, with higher differences between seasons during the eutrophic period. The development of vertical niches in phytoplankton traits was highest during periods with strong thermal stratification and this pattern did not change with oligotrophication.

47. *Harriet L. WILSON[1], Ian D. Jones[2], Don Pierson[3], Hans-Peter Grossart[4], Alec Rolston[1], Eleanor Jennings[1]*

Identifying extreme episodic events in the water column: Challenges and applications

[1]Centre for Freshwater and Environmental Studies, Dundalk Institute of Technology, Dundalk, Ireland
[2]Center for Ecology & Hydrology, Lancaster Environment Centre, Lancaster, United Kingdom
[3]Department of Ecology and Genetics/Limnology, Uppsala University, Uppsala, Sweden
[4]Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Stechlin, Germany

The impact of extreme episodic events on the physical, chemical and biological processes in lakes is an important concern. The mixing mechanisms associated with wind stress and surface cooling have important impacts on lake ecosystem functioning, for example, through the supply of light and nutrients for phytoplankton growth and the replenishment of oxygen to the hypolimnion. In addition, there is a growing understanding that extreme events may be just as important as annual variation in driving long-term ecological change.

Therefore, in order to explain chemical and biological changes in lakes, it is often necessary to identify and characterise extreme mixing/stratification events. Within the literature, there are many different methods and metrics used which utilise different physical concepts. Consequently, the use of different metrics and methods can yield different descriptions of the mixing occurring in a lake, causing uncertainty as to the effect of mixing events. In addition, the use of critical thresholds and temporal resolutions can often be arbitrarily applied. Although there is no 'true' statistical representation of mixing in lakes, some methods are better suited to certain applications.

The first part of this project entails investigating the limitations of different methods for identifying extreme events and exploring the possibilities and challenges of finding a 'robust' method that can be used across temporal scales, lake morphologies and climates.

48. Bronwyn L. WOODWARD[1], Jatin Kala[2], Matt Hipsey[3] and Carolyn Oldham[1]

An evaluation of the Weather Research and Forecasting model in simulating the meteorology over Lake Argyle in north Australia

[1]School of Engineering, University of Western Australia, Perth, WA, Australia
[2]School of Veterinary and Life Sciences Environmental & Conservation Sciences, Murdoch University, Perth, WA, Australia
[3]UWA School of Agriculture and Environment, University of Western Australia, Perth, WA, Australia

When spatially varying meteorological field data is not available, outputs from regional climate models (RCMs) may be used to improve hydrodynamic modeling of lakes. The Weather Research and Forecasting (WRF) Advanced Research (WRF–ARW) modeling system is one of the most widely used RCMs. We test the sensitivity of WRF to different Lake Surface Temperature (LST) inputs and different model physics parameterisations to give confidence in using WRF outputs to run a three dimensional hydrodynamic model of a tropical reservoir. We compare the sensitivity of the horizontal variation in the WRF boundary simulation to the sensitivity of the output at the lake interior to these parameters. The sensitivity analysis allows us to weigh the effort of inputting a more accurate LST to improve the accuracy of WRF outputs, when the outputs are to be used as forcing data in hydrodynamic simulations.

New Site Abstracts

1. *Josef HEJZLAR[1], Jan Kubečka[1], Jiří Peterka[1], Jaromír Seďa[1], Karel Šimek, and Petr Znachor[1]*

New GLEON site: Římov Reservoir – a temperate dimictic water body with a 40-year limnological record of regional socio-economic development and climate change

[1]Institute of Hydrobiology, Biology Centre CAS, České Budějovice, Czechia
[1]Department of Zoology, Miami University, Oxford, Ohio, USA
[2]Center for Limnology, University of Wisconsin-Madison, Madison, Wisconsin, USA

The Římov Reservoir is a deep-valley reservoir (48°49’58’’N/14°29’30’’E; elevation, 471 m a.s.l.; area, 2.0 km^2; volume, 34 hm^3; z_{max}, 43 m; HRT, 0.2 yr) built in 1978 to store drinking water by damming a 13-km section of the River Malše, the main tributary accounting for ca 90% of the inflow. The reservoir is filled by headwaters from a hilly catchment (489 km^2) covered mostly by forests (54%) and partly with arable land (9%), grassland (34%) and urban areas (2%). The reservoirs has been monitored at the dam by the Institute of Hydrobiology since its filling in 1979 regularly at three-week intervals for physics (transparency, stratification of temperature, DO, pH, alkalinity), hydrochemistry (major ions, nutrients – forms of C, N, P, Si), plankton (phytoplankton biovolume and abundance, zooplankton, bacteria, HNF and ciliates) and fish (biomass, abundance and species composition). High frequency (HF) buoy climatic and temperature-stratification data have been recorded since 2006 and another HF buoy station for DO, pH, chlorophyll-a, and DOM stratification was set in operation in 2018. This monitoring programme has so far provided much insight into trends and their causes in the areas of hydrology, climate change, and the impact of eutrophication on the aquatic ecosystem.

Site News Abstracts

49. Hilary SWAIN[1] and Evelyn Gaiser[2]

A next-generation instrumented buoy for Lake Annie, Florida

[1]Archbold Biological Station, Venus, Florida, USA
[2]Florida International University, Miami, Florida, USA

The 36-ha, 21m deep Lake Annie on Archbold Biological Station in Florida, is a monomictic subtropical, oligotrophic, humic lake. Celebrated for its history of paleo research (44,000 year sediments), monthly limnological sampling (since 1983), and (since 2008) an instrumented buoy, Lake Annie has contributed extensively to GLEON. NSF recently awarded funding for Archbold to deploy a highly-instrumented profiling buoy, expanding data collection for GLEON and other collaborations. We describe the upgrade to a FlyDog OSCAR profiling buoy, with an EXO1 Sonde and AirMap climate station, and adding new sensors on an EXO2 Sonde for continuous profiling (0 to -19m) of D.O., pH, total algae and chlorophyll, temperature, conductivity, and fDOM, as well as light, and surface measures of heat fluxes, solar radiation, and CO2. These data will contribute to projects addressing: (i) lake metabolism (CO2 and DO profiles); (ii) controls of high frequency variance in algal production and colored organic material (depth-resolved fluorescence); (iii) spatiotemporal heterogeneity controlling highly variable phytoplankton dynamics; (iv) and mixing, heat flux, and solar radiation for climate and physical modeling. The buoy will allow flexible maintenance, enhance access to real-time data, and expand data management, adding to the 2-million record Annie dataset online via CUAHSI. Broader impacts include a module for K-12 education, student training, interpretive signage, more citizen science, science-arts events and a new video about Lake Annie.