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Poster Session Abstracts

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DataONE

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Estimation of ecosystem metabolism from high frequency data in a saline shallow lake: La Salada (Argentina).

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Continuous monitoring of changes in dissolved oxygen concentration (DO) allows the estimation of ecosystem metabolism and provides a measure of the overall activity of an ecosystem, summarizing the biogeochemical and trophic processes, and determining the efficiency of resource processing. The aim of this study was to determine the temporal dynamics and regulation of the ecosystem metabolism in a saline shallow lake, La Salada, located in the South of Buenos Aires Province, Argentina. We estimate net ecosystem production (NEP), ecosystem/community respiration (R), and gross primary production (GPP) rates, in relation to physico-chemical and climatic variables for 18 months. Net autotrophic conditions prevailed during the study period (NEP = 64.05 ± 44.22 mmol O_2 m^{-2}). Annual and interannual variation of water level seems to be a major factor influencing the ecological processes in the system, as well as temperature and conductivity due to evapoconcentration. GPP and R followed a similar pattern over time, with GPP over R, implying that La Salada is a very productive ecosystem and produces significantly more organic material than it is able to degrade. The excess may either be exported to adjacent systems and/or accumulate within the system.

2. *Vanina S. Aliaga [1,2,4,5], Federico Ferrelli [1,2,4], María C. Piccolo[1,2,4,5], Gerardo M.E. Perillo [1,3,4,5]*

PRELIMINARY STUDY OF CLIMATE VARIABILITY IN LA PICASASHALLOW LAKE, SANTA FE PROVINCE, ARGENTINA

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Climate variability is one of the most important topics to understand the spatial dynamics of water bodies. This variability may cause economical impacts on tourism, decrease in fishing and damages due to the floods. In La Picasa shallow lake, located in Santa Fe Province, Argentina extreme events are challenging public institutions to focus on developing adequate structures mainly to mitigate the occurrence of floods. In the last decade, hydrological events affected the local population and their activities. We present the preliminary results of the analysis of the effects of climate variability on La Picasa shallow lake. Data from a meteorological station located northeast of the lake was processed. The study period is 1960-2010. Decadal, inter-annual and inter-seasonal time scales were applied to analyze this information. Satellite images were processed to characterize the spatial dynamics. Results showed that wet extreme events were more intensive than dry ones. The positive anomalies of precipitation ranged between 500 to 800 mm per year, while the negative ones between 300 to 350mm per year. During the study period, the mean temperature increased 0.5 ºC. Thermal anomalies ranged between +/- 1ºC. In addition, the relative humidity increased 5 % and the variations of wind intensity were significant along the period. These analysis results could be useful to public organisms that are working on lake management.

3. *Shelley Arnott[1], Bill Nelson[1], Lauren Grubb[1], Julie Marais[1], AshleyBramwell[1], Phil Anderson[1]*

Connecting life-history traits to ecosystem function to understand lake response to climate change

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Climate change is predicted to have a major impact on the thermal structure of freshwater lakes. There is ample evidence from long-term monitoring that lakes around the world have experienced increased mean temperatures, increased length of ice-free seasons, and changes in thermal stratification. Despite our knowledge of the observed and anticipated changes in lake thermal structure, we have a poor understanding of their impact on ecosystem function. This is a surprising because we know a lot about how temperature impacts aquatic ectotherms. Warmer water causes increased metabolism and feeding rates, which cause changes in life history such as increased birth, growth and death rates. The challenge is that we do not understand how changes in individual life history traits scale-up to influence ecosystem function. Our research addresses this problem by combining high-resolution environmental monitoring with estimates of secondary production using in-situ methods and individual-scale life-history experiments. One hundred Daphnia, the dominant herbivore, were sampled from Elbow Lake, ON at two-week intervals throughout the ice-free season and grown in the lab under standardized food conditions at 15°C and 25°C. We found that individual growth rates of Daphnia changed throughout the season, suggesting that changes in secondary production throughout the season may be attributable, in part, to seasonal changes in genetic structure. We combined high-resolution lake temperature data with lab-based growth rates to estimate changes in secondary production throughout the season. This experiment allowed us to quantify

the relative importance of genetic structure and temperature to explain seasonal changes in secondary production.

4. *Roxanna Ayllon[1], Luciano Caputo[2], Brian Reid[3], Luis Uribe[3], Dayane Osman[2], Wara Marcelo[4], Romina Fuentes[2]*

Lakes as Sentinels in Chilean Patagonia: Community-Based Approach to Monitoring Global and Local Change in the Landscape

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The concept of lakes as sentinels of change in the landscape and recent advances in high-frequency monitoring networks, has propelled innovative global collaborations dedicated to long-term monitoring and research e.g. GLEON, Globolakes, Limnades. Nevertheless, there are obstacles to implementation in less developed regions: high start-up cost for instruments, limited resources for periodic travel to remote areas, limited potential for long-term sustainability, and vulnerability from lack of maintenance or on-site supervision. Currently, long-term monitoring lakes in Chile has limited spatial representation (central and North Patagonian regions) and low-frequency (3-4 synoptic samples annually since the 1990s). We propose a simple, low-cost buoy for high frequency monitoring with increased emphasis on citizen participation to supplement the existing monitoring and address many of the present limitations. Buoys installed in paired small and large lakes provide high-resolution information on lake thermal structure (climate response) and lake transparency (land use effects on algal productivity and/or, suspended sediments). Periodic monitoring campaigns conducted with participation of local stakeholders provide data for more traditional indicators (secchi depth, nutrients and chlorophyll concentration). Citizen-based monitoring builds active participation, puts environmental education in a local context, increases the understanding of the need for long-term monitoring, and thereby hopes to increase the long-term security of the monitoring infrastructure. Taken together, synoptic sampling can be viewed in the context of near real time lake dynamics, for more effective long-term monitoring, and building a greater public appreciation for more complex management issues e.g. local ecosystem health in the context of global and local change.

5. *Sarah L. Bartlett[1], Chelsea A. Weirich[2], Todd R. Miller[2]*

Toxic Blue-Green Algal Peptides in Drinking Water Sources: Temporal Dynamics at High Speed

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The temporal variability of cyanobacterial blooms and toxic metabolites was studied in a eutrophic lake used for drinking water production at high resolution from August to October, 2013using water quality measurements and automated water sampling from a buoy deployed near Oshkosh, WI. Lake Winnebago is the largest inland lake in Wisconsin and part of the Lake Michigan watershed. This lake serves as a drinking water resource to four major cities and experiences large accumulations of toxic cyanobacteria of *Microcystis* and *Aphanizomenon* genera in late summer/fall due to nonpoint-source nutrient inputs from the Fox River Basin. Targeted toxins in this study include microcystins (LR, YR, LA, RR), anatoxin-a, homoanatoxin-a, and cylindrospermopsin, in addition to the following bioactive peptides – anabaenopeptins (A,F), cyanopeptolins (1007, 1020, 1041), and microginin 690. To our knowledge, this is the first study to monitor the variability of cyanobacterial toxic and bioactive peptides at high-resolution (4X per day) for several months. Detection of secondary metabolites from lyophilized water samples was achieved using HPLC-electrospray ionization tandem mass spectrometry. Measured concentrations of microcystins produced throughout the sampling season revealed MC-LR was the dominant toxin, with a mean concentration of 2.07 ug/L (maximum= 12.85ug/L). We found multiple toxins or otherwise bioactive molecules co-occur during the same bloom events, and the average production of all peptides was 5.61 ug/L (maximum = 30.49 ug/L). We also found that toxin levels can change rapidly on an hourly basis by 2 – nearly 10 – fold at a given sampling location, or drinking water intake.

6. Lucas J. Beversdorf[1] and Todd R. Miller[1]

Eliciting the factors that control microcystin production in *Microcystis aeruginosa*

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The environmental drivers contributing to cyanobacterial dominance in aquatic systems have been extensively studied from the molecular to the global scale. However, our understanding of the cellular pathways, physiological functions, or ecological advantages of cyanotoxin production is still lacking. Recently, two studies showed that the nitrogen (N) control gene product NtcA is intricately involved in the activation of microcystin (MC) genes by binding to the *mcyA/D* promoter region of the MC operon. We hypothesize that MC production is under the influence of carbon (C) and N metabolism in *Microcystis aeruginosa*, specifically the levels of ammonium (NH_4^+) and 2-oxoglutarate (2-OG) that control NtcA. We also hypothesize that increased C:N ratios in the environment would indicate increased MC concentrations. To test this, we manipulated 2-OG and NH_4^+ concentrations in two different strains of toxic *M. aeruginosa* and measured C:N and 2-OG: NH_4^+ ratios, as well as MC concentrations. We also measured C:N ratios and MC concentrations in Lake Winnebago, WI, a eutrophic lake that experiences chronic, noxious *Microcystis* blooms. Our results indicate that N limitation and/or excess C in *M. aeruginosa* is a prerequisite for increased MC expression and may provide toxic strains with an advantage during times of cellular stress.

7. *José F. BEZERRA-NETO[1] , Nelson A. S. T. Mello[1] , Guilherme S. D. Andrade[2] , Gilberto C.B.[2] , Melo , Cláudio L. Souza[2]*

Methane diffusive processes in tropical waters: Occurrence of non-Fickian flux?

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Studies in boreal lakes on the diffusive flux of methane has questioned whether this greenhouse gas (GHG) would follow the same process in the diffusive air-water interface as other bioactive gases such as oxygen and carbon dioxide. The origin of these questions stem from the differences in the values of K600 to methane and carbon dioxide derived from measurements of gas flux through the use of floating chamber and the partial pressure of these gases in air and water. It was observed that the K600 values derived from the CH4 were larger than the CO2-based values in 90% of cases. Such a discrepancy would indicate that these gases would behave differently between systems, characterizing the presence of a non-Fickian diffusion component of methane and the possible occurrence of a flow of microbubbles in this process. The aim of our study was to compare the values of K600 between methane and carbon dioxide, measured in different compartments of lakes and tropical reservoirs, using the same methodology described above. In addition, model was tested to flow of micro-bubbles of methane generated for boreal Lakes, in order to verify that such a process occurs similarly in tropical environments.

8. *Matthew J. Bogard[1,2], and Paul A. del Giorgio[1,2]*

Assessing the drivers of aquatic ecosystem respiration

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Aquatic community respiration (R) is a basic ecosystem process that plays a central role in planetary catabolism and in sustaining the earth's greenhouse effect. Despite its importance to ecosystem functioning and C biogeochemistry, R remains poorly understood from a mechanistic point of view. Empirically, R is related to multiple ecosystem features, including trophic status and algal dynamics, dissolved organic carbon (DOC) content, geomorphology and hydrology. Yet these features generally covary, thus making it difficult to establish a precise mechanistic understanding of R. Here, we establish a conceptual framework for the regulation of R, which we test using hundreds of measurements from diverse lake, wetland, and river environments. We base this framework around the fact that R represents the mineralization of separate autochthonous and allochthonous dissolved organic matter (DOM) pools, which are controlled each by their own suite of environmental features. We further account for

the fact that these pools can interact, largely in cases where allochthonous DOM is highly colored and under different circumstances, can limit or enhance ecosystem photosynthetic capacity, autochthonous DOM production, and its subsequent mineralization. Finally, we use this framework to reconcile the divergent relationships between R and environmental features that exists among lotic and lentic systems.

9. *Lyubov Bragina[1], Orla Sherlock[1] and Eleanor Jennings[1]*

Pathogens and faecal indicator bacteria in streams and sediments in a rural agricultural catchment

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Faecal coliforms including *Escherichia coli* are commonly used as faecal indicator bacteria (FIB) of recent contamination of water bodies with human or animal waste. Studies have shown that aquatic sediments can also contain elevated levels of FIB, that these can persist in sediments for months and can re-contaminate the water column during high flows. There is little work, however, on contamination of sediments in agricultural catchments and none relating to the impact of streamside fencing on levels. Sediment samples were collected from three headwater tributaries within the Milltown Lake catchment, an agricultural catchment in County Monaghan, in April, July, and October 2013. Samples were also collected from a catchment in a site which has no intensive cattle production. Preliminary data showed that all sites in the Milltown Lake catchment were heavily contaminated with faecal coliforms (both total faecal coliforms and with *E. coli*) and that values were highly variable both between tributaries and from site to site. Concentrations of *E. coli* in the Milltown Lake sediments ranged from 4.0×10^1 to 1.3×10^6 CFU g^{-1} d. w. Values were highest where cattle had access to the stream. More importantly concentrations were significantly lower in a fenced stream than in two unfenced streams. A significant positive correlation was also found between *E. coli* concentrations in sediment and *E. coli* in the overlaying water ($r = 0.69$, $p = 0.00$). Future work will include investigations of the conditions under which FIB are resuspended, and persistence of pathogenic bacteria in sediments.

10. *Jennifer A. BRENTRUP,[1] Craig E. Williamson,[1] Werner Eckert,[2] Elvira de Eyto,[3] Hans-Peter Grossart,[4] Lesley B. Knoll,[5] Alo Laas,[6] Taylor H. Leach,[1] David da Motta Marques,[7] Chris G. McBride,[8] Francesco Pomati,[9] Jordan S. Read,[10] Elizabeth Ryder,[11] Peter A. Staehr,[12] Luke A. Winslow[10]*

Using profiling buoys to look below the lake surface: An analysis of vertical chlorophyll dynamics across space and time

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Using high-frequency sensors to improve the understanding of biological processes occurring in lakes is a rapidly growing field that is beginning to provide new insights into lake dynamics on sub-daily timescales. Instrumented lake buoys are capturing depth distributed physical measurements and biological data at the surface on lakes globally; however, systems using an automated winch and sensor package to vertically profile the water column are now gaining widespread use in order to understand chemical and biological processes below the surface. At present, there are nine GLEON sites with profiling buoys so a new collaboration among sites is focused on understanding high-frequency vertical chlorophyll and oxygen dynamics in a range of oligotrophic to eutrophic lakes located in both the northern and southern hemispheres. A specific aim is to examine the timing and causes of deep chlorophyll maxima (DCM) that exists in many lakes. Limited information is presently available on how DCMs change seasonally and how they respond to disturbance events such as storms. Preliminary analysis of chlorophyll fluorescence data from the profiling buoys will be presented here along with other limnological and meteorological variables to examine patterns in the DCM and how they vary across a range of lakes. Additionally, we propose that high-resolution temporal and vertical measurement of phytoplankton dynamics using profiler buoys could improve our understanding of food web dynamics, as well as the metabolic balance of different strata in the lake, with important implications for the role of lakes in carbon cycling.

11. Ludmila S. BRIGHENTI[1], Peter A. STAEHR[2], Francisco A. R. BARBOSA[1], José Fernandes BEZERRA-NETO[1]

Seasonal changes in metabolic rates of two tropical lakes: The role of water column stability

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We investigated the importance of environmental drivers for the seasonal dynamics of gross primary production (GPP), ecosystem respiration (R) and net ecosystem production (NEP) in two tropical lakes in southeast Brazil (Carioca – CA; and Dom Helvécio - DH), during 2011 and 2012, using high frequency measurements of dissolved oxygen (DO). Metabolic rates were approximately twice as high during the fully-mixed winter periods (CA GPP 86.7 ± 58.2 mmol O_2 $m^{-3}d^{-1}$; R 92.6 ± 75.5 mmol O_2 m^{-3} d^{-1}; DH GPP 38.6 ± 22.5 mmol O_2 m^{-3} d^{-1}; R 43.5 ± 34.6 mmol O_2 m^{-3} d^{-1}; mean ± standard deviation), compared to the summer periods (CA GPP 39.0 ± 22.7 mmol O_2 m^{-3} d^{-1}; R 42.6 ± 31.0 mmol O_2 m^{-3} d^{-1}; DH GPP 23.0 ± 13.0 mmol O_2 m^{-3} d^{-1}; R 17.9 ± 19.0 mmol O_2 m^{-3} d^{-1}). For both lakes, GPP was about 30% lower during the warmer and dryer spring of 2012 compared to 2011. Seasonal changes in GPP and R were negatively correlated to SchmidtStability. Periods with high stability coincided with warm waters which reduced mixing and internal inputs of nutrients from hypolimnetic waters. GPP was accordingly suppressed in both lakes during summer due to a combination of nutrient depletion and photo-inhibition. These conditions were more pronounced during 2012, the warmer and more dry year.

12. Rafael Cavalcanti[1], David da Motta-Marques[1], Carlos Ruberto Fragoso Junior[2]

Process-based modeling of lake metabolism and its relations with wind-driven hydrodynamics

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This work is based in a process based model was used to evaluate distributed estimates of lake metabolism (GPP, R, and NEP) and its relations with the wind in a shallow subtropical large lake (Lake Mangueira, south coast of Brazil). A process-based algorithm was implemented within an existing complex dynamic ecological model in order to evaluate lake's metabolism. The algorithm is based on O_2 concentration budget and it takes into account many processes that can promote variations in O_2 concentration for both, water and sediment compartments. In order to account the wind influence on metabolism estimations, a total set of five wind scenarios were simulated. Each scenario took into account changes in wind direction and / or magnitude. For the distributed analysis of lake metabolism, the lake was divided into four regions (north, central, south, and the lake as a whole), and in two biological zones (pelagic and littoral). Lake Mangueira metabolism estimations (GPP, R, and NEP) showed a strong temporal and spatial pattern, with different temporal patterns among the biological zones. The results also showed that the wind can alter Lake Mangueira metabolism. Each region responded differently to changes in wind regime, and the wind direction was more important than the wind speed as a factor to alter lake metabolism.

13. Luciano Caputo[1,2], Dayane Osman[1], Giuseppe Alfonso[3], Ricardo Giesecke[1,2] and Stefan Woelfl[1]

Summer phytoplankton distribution on 15 Chilean lakes located along a climate gradient in Chile, 32 - 40°S

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Fifteen lakes distributed along a N-S climatic gradient in Chile (32 - 40 °S), covering an altitudinal range from 64 to 2800 m.a.s.l, were studied at the end of the austral summer. In this study, contrary to expectations, the mixing layer did not show a trend of increased vertical extension in those lakes southward located along the latitudinal gradient of temperature. The environmental classification, based on the similarity of 15 independent limnological parameters, determines 4 groups of lakes that adequately represent phytoplankton attributes and vertical patterns of chlorophyll-a distribution. Stratified lakes in central Chile (>2000 m.a.s.l) developed deep chlorophyll maxima close to the theoretical light compensation depth zone. In contrast, lakes in central-southern Chile (below 800 m.a.s.l) generally had maximum chlorophyll within the epilimnetic strata. In this study, a fluorometric phytoplankton characterization was performed in situ using bbe FluoroProbe revealing a distinctive pattern of chlorophyll-biomass dominance of the "brown spectral group" in all lakes. This fluorimetric characterization was consistent with the microscopic analyses of phytoplankton. Both community structure and floristic composition of phytoplankton was dominated or co-dominated by the biomass of dinophytes and diatoms species. The functional group L0, based on the phytoplankton classification of Reynolds et al. 2002, was the more ubiquitous in lakes (n = 11) reflecting a regional synchrony in the Andean plankton dynamic. L0 typically was represented by the dinoflagellate dominance, genus Gymnodinium, Peridinium and Ceratium. High altitude lakes of central Chile were only represented by the functional group B, central diatoms dominance.

14. Alicia M. Caruso[1]

Evaluating the application of lake buoy data in managing water resources

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Environmental degradation is occurring at an accelerated rate. Scientists are capturing some of these changes through the use of high-frequency sensor networks. The information they gather can be crucial to decision making about natural resources, but the communication between scientists and decision makers is not always effective. My thesis looks at one network of researchers–the Global Lake Ecological Observatory Network (GLEON)–that is collecting high-frequency data from lake buoys in order to do global-scale research. The first goal of this study is to determine what is being done these data and whether they are being used in any environmental decision-making capacity. The second goal is to examine use of GLEON data at one site–Taihu, China–where there is an established record of communication between scientists and local

environmental officials. I conducted surveys of contacts from GLEON and interviews with Taihu officials and discovered that there are applications of high-frequency data in environmental decision making. I also determined that there are ways to encourage the use of high-frequency data in decision making, such as better communication between the two groups, better training in cyberinfrastructure, and better mutual understanding of each group's responsibilities.

15. Sudeep Chandra[1], Alicia Brantley[1]

Community respiration rates in lakes across a trophic gradient: contributions from pelagic and littoral habitats

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Community respiration contributes to the metabolic balance of lakes and is driven by organic and inorganic nutrients and organic carbon. However, little is known about how community respiration from littoral benthic and pelagic habitats varies in lakes across a trophic gradient. Here, we quantify pelagic and littoral benthic community respiration (CR) rates in 9 lakes along a trophic gradient, with a focus on within habitat variability, and the change in relative contributions of littoral benthic and pelagic CR to whole-lake CR. CR rates were measured using biochemical oxygen demand techniques with a dark incubation period. In all lakes along a trophic gradient, CR rates in the littoral benthic habitat were higher and more variable (0.71±0.75 mg CO_2 L^{-1} day^{-1}) than in the pelagic habitat (0.30±0.36 mg CO_2 L^{-1} day^{-1}). Variability in littoral zone CR decreased with an increase in trophic state. Additionally, the relative contribution of pelagic CR rates to whole-lake CR rates increased (16.4-38.1%) with an increase in trophic state; the highest relative contribution from the pelagic habitat occurred in a hyper-eutrophic lake which had the highest levels of total phosphorus and dissolved organic carbon. These results emphasize the importance of trophic state and habitat type (littoral vs. pelagic) on the magnitude and variability of community respiration rates; ultimately informing carbon budget estimates for different lake types.

16. François Clayer[1], Charles Gobeil[1], and André Tessier[1]

Modeling methane diagenesis in lake sediments

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Triplicate porewater depth-profiles of methane (CH4) and of other key solutes including nitrate, Mn, Fe, sulfate, total sulfide, organic and inorganic C and major ions were determined in two basins from a Canadian Shield lake. One of the basins sporadically develops anoxic bottom waters but both basins were oxygenated at sampling times. Porewater profiles were modeled using a one-dimensional transport-reaction equation in order to constrain the depth-intervals (zones) where CH4 and other key solutes are produced or consumed in the top 10 cm of the sedimentary column, as well as to obtain the net reaction rates in each of the zones.

Modeled net reaction rates profiles show that, in both basins, CH4 is produced below 4 to 6 cm sediment depth and consumed above this depth horizon, 2) that, in contrast to the perennially oxygenated basin where rates of CH4 production and consumption are similar, rates of methanogenesis in the sediment of the other basin are 40 times higher than rates of methanotrophy. A mass balance calculation is then used to obtain an estimation of the relative contribution of the acetoclastic and hydrogenotrophic pathways to total methane production. It also provides clues to identify the main electron acceptor for the anaerobic oxidation of CH4 (AOM). Finally, we will show that methanogenesis represents only 7% of total C mineralized in the always oxic basin against 80% in the sporadically anoxic basin.

17. Jessica R. Corman[1], Jorge Ramos[1], Daniel Childers[2], and James J. Elser[1]

Springs, ponds, and pools: Spatial and temporal variability of spring ecosystems in Cuatro Ciénegas, MX

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Groundwater springs provide vital water resources in deserts. The Cuatro Ciénegas (CC) Valley, México, hosts >300 aquatic features (springs, ponds, and pools) and numerous endemic species. The hydrology of this region in the Chihuahuan Desert is poorly understood. We have monitored the physicochemical characteristics here since 1998 and yearly since 2011. CC aquatic ecosystems have impressive spatial physicochemical variability. Specific conductivity spanned 1.1 – 9.6 mS/cm2. Dissolved organic carbon ranged over two orders of magnitude (max: 5.3 mM). Total dissolved N and P reached>500 uM N and 10.8 uM P in different ponds. Atomic N:P ratios ranged from 7 – 997. The highest (>500) and lowest (<20) N:P ratios were found in neighboring features suggesting that organisms are experiencing different nutrient constraints on small spatial scales. In 2010, Hurricane Alex caused heavy rainfall (>27 cm) in CC, but influenced aquatic ecosystems dissimilarly. While rain events temporarily increased nutrient concentrations in Río Mesquites, a perennial stream, we detected no long term disturbance. Conversely, we observed long-term effects of the hurricane in the perennial and ephemeral ponds of Los Hundidos. The water levels increased over 2 m after the hurricane and remained elevated for >12 months. After nearly 2 years, mean conductivity values were still less than 30% of pre-storm values. Our results stress the importance of long-term and valley-wide studies in climate-sensitive aquatic ecosystems in desert regions. The results also suggest that a simplified view of the hydrology may mask important spatial variability in the region.

18. Paula S. COSTILLA[1], Belén Bertoni[1,2], Carina Seitz[1,3,4], Paula A. Zapperi[1,3], M. Cintia Piccolo[1,3,4] and Gerardo Perillo[1,3,4].

Initial progress of the SAFER education program about lake conservation and use.

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Since one of the main milestones of the SAFER project is to develop a children's educational program about lake conservation and use, the objective of this article is to present the first achievements of its implementation. La Salada Lake, nearby to Pedro Luro City, Argentina, was the chosen place to start and test the program. As a first stage, basing the structure on an ethnographic fieldwork, nearby schools were identified in order to establish contact with teachers concerned with socio-environmental approach related with the lake. This allowed a second working instance that involved the participation of a high school teacher whose main interest is in Society Development and Environment. In this framework, an educational and participatory research strategy was established and conducted through a field trip with 16 students. The methodology was planned to strength cognitive skills like: observation, description and explanation of natural processes. The trip consisted on dialoguing with inhabitants of the La Salada neighborhood and following a path around the lake to observe and take records of vegetation and wildlife. As an in situ activity in the lake, physico-chemical parameters were measured by multisensor profiles and water samples were taken to identify the zooplankton and phytoplankton species. Finally, the students, with the professor advice, submitted a research proposal to a regional science fair. Another important achievement is related to the integration of different disciplines applied to understand the lake. From the comments of the students, the activity exceeded their expectations over the fieldwork and they were willing to develop further activities.

19. Yang Cui[1]

Simulating the response of phytoplankton blooms to nutrient reduction by DYRESM-CAEDYM in Shahe Reservoir, China

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Water eutrophication is a key problem for reservoirs in China, and threatens water supply safe and tourism quality. External nutrients loading input contribute a lot to water eutrophication and phytoplankton blooms. Therefore, reductions of external nutrients loading are necessary to reduce water column nutrient concentrations and mitigate phytoplankton blooms. Through a field study in Tianmuhu Shahe Reservoir, China, and an application of DYRESM-CAEDYM model, this study quantitatively made a reduction of external nutrients loading to decrease phytoplankton biomass. DYRESM-CAEDYM was calibrated against field data for a two-year period and validated one-year period. Model simulations of water temperature, oxygen, total nitrogen, total phosphorus, and chlorophyll a concentrations showed good agreement with field measurements. The model could successfully capture the seasonal blooms of phytoplankton, indicating spring peak

values of diatoms and summer peak values of cyanophytes. Model simulations indicate that the control of combined external nitrogen and phosphorus loading appear to be more effective in reducing phytoplankton biomass than alone external nitrogen or phosphorus loading, tending to adopt a combined nitrogen and phosphorus loading reduction. A combined 50% reduction of external nutrients loading could decrease phytoplankton biomass lower than 6 µg/L in Shahe Reservoir.

20. Blaize Denfeld[1] and Gesa Weyhenmeyer[1]

Under ice CO_2 dynamics in lakes across the boreal region

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Several global CO_2 emission estimates from lakes are available but temporal, in particular seasonal, variations are rarely considered. Most of the lakes in the northern hemisphere are, however, ice-covered during substantial portions of the year. Ice acts as a barrier to atmospheric exchange causing high concentrations of CO_2 to accumulate in lakes. At present, only a very limited number of global CO_2 emission estimates from lakes include emissions at ice melt and are based on simple assumptions rather than evidence. The few studies investigating temporal and spatial CO_2 dynamics during ice cover highlight the complexity and importance of under-ice CO_2accumulation and subsequent CO_2 evasion at ice melt. Yet, these studies are limited in their ability to account for CO_2spatial variability across lake morphologies and climate regimes. Using GLEON as a platform, we combined here, for the first time, temporally robust CO_2 measurements from the ice-covered period across a spatially diverse set of lakes. We intend to assess the control of lake morphology and climate regimes on in-lake CO_2accumulation below ice and subsequent CO_2 evasion at ice melt. Given that boreal and arctic regions are ice-covered for a significant portion of the year, adequately accounting for CO_2emissions during ice melt based off evidence rather than assumptions are essential for global CO_2 emission estimates.

21. Jonathan P. Doubek[1], Cayelan C. Carey[1], and Bradley J. Cardinale[2]

Anthropogenic land use increases N–fixing cyanobacterial dominance in lakes across the continental United States

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Cyanobacteria are a leading cause of many lake water quality problems worldwide. Because of their negative impacts, it is important to quantify factors that drive cyanobacterial biovolume and dominance, both within a lake (e.g., nutrient concentrations) as well as in the watershed (e.g., land use). Although many studies have examined multiple factors that control cyanobacteria, few studies have explicitly quantified the effects of land use for a diverse array of cyanobacterial taxa at the

continental scale. We analyzed data from the 2007 U.S. Environmental Protection Agency's National Lakes Assessment to quantify patterns of cyanobacterial dominance in 236 glacially–formed lakes spanning the continental U.S. Cyanobacterial dominance was positively associated with changes in lakeside agriculture and human–developed land use. This pattern was driven by N–fixing cyanobacterial taxa such as *Anabaena* and *Aphanizomenon*. Conversely, there was no relationship between land use and non–N–fixing cyanobacteria such as *Aphanocapsa* and *Microcystis*. Consistent with prior evidence, shifts to cyanobacterial dominance were associated with increasing nutrient concentrations that commonly accompany changing land use. However, anthropogenic land use was a stronger predictor for cyanobacterial dominance, whereas in–lake nutrient concentrations were stronger predictors for cyanobacterial biovolume. Therefore, there are effects of anthropogenic land use other than increased nutrient concentrations (e.g., warmer surface temperature, increased sedimentation) that drive cyanobacterial dominance. Consequently, management strategies to control cyanobacteria need to account for the variation in life–history traits of different taxa, and whether the lake is to be managed for total cyanobacterial biovolume or cyanobacterial dominance.

22. Gaël Dur[1], Orlane Anneville[1], Yongxiang Huang[2], and Sami Souissi[3]

Multiscale cyclicity of Cyanophycea and Zygophycea in Lake Geneva

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Zygophycae and Cyanophycae have a strong impact on the ecological quality of lentic ecosystem. In Lake Geneva, their abundances increased despite the switch from eutrophic to mesotrophic status. Using long-term data (1974 -2010) of phytoplankton biomass and composition, we investigated the dynamics of those algal groups at different time scales and identified the triggering environmental factors of long-term cyclicities. We performed wavelet analysis to identify cycles and transient relationship with environmental factors. We then used time-dependent intrinsic correlation (TDIC) analysis to examine the relationships between the time series. The wavelet analysis showed that the two groups exhibit not only annual cycles (associated with the seasonality of environmental conditions) but also longer cycles. These two taxa present a 4yr cycle between 1980 and 1990 with a strong coherence with the NAO and the duration of insolation. The TDIC revealed that, for this period, the relationships with NAO and duration of insolation are in phase for Cyanophycae and in antiphase for Zygophycae. For both group, an inversion of phase correlation with NAO was observed around 1998. The two groups also exhibit an 11yr cycle that could be associated with sun spot variation, but longer time series would be necessary to confirm that observation. Zygophycae has also been displaying a 4yr cycle, since the end of the 90s, associated with the variation in the abundance of herbivore zooplankton, especially

the calanoid copepod Eudiaptomus gracilis. Our approach allowed the identification of relationships existing in the complex system of Lake Geneva.

23. C. Emi FERGUS[1], Samantha Oliver[2], Nicholas Skaff [1], Caren Scott[1], Patricia A. Soranno[11], Kendra S. Cheruvelil[3], Katherine Webster[4], Mary Bremigan[1]

Measuring patterns of lake, stream, and wetland connectivity at macroscales

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[4]Department of Zoology, Trinity College, Dublin, Ireland

The importance of lakes, streams, and wetlands (i.e. inland freshwater features) in regional and global biogeochemical cycles is becoming widely recognized. It is expected that the relative role of freshwater features in these processes is influenced by their hydrological connections. These connections control the movement, biogeochemical storage, and transformation of nutrients and materials across the landscape. However, it can be challenging to integrate freshwater systems in a macroscale framework because 1) lakes, streams, and wetlands are frequently studied separately, 2) there are few inventories on their abundance, distribution, and connections at broad geographic extents, and 3) there are few freshwater connectivity spatial metrics that can be applied at broad spatial extents. To understand how freshwater features and their connections vary across regions, we identified existing landscape metrics and developed our own measures that quantify lake, stream, and wetland surface hydrological connections using national geographic information systems (GIS) data coverages. We quantified regional variation in freshwater connectivity in the Midwest and Northeast (US) regions using linear mixed-effects models and identified multi-scale hydrogeomorphic, land use, and climatic variables associated with the freshwater connectivity metrics. We found that not only the average density of lakes, streams, and wetlands differed across regional extents, but also that the types of freshwater connectivity differed across regions. Local and regional scale landscape variables accounted for some of this variation. With these results, we can estimate the distribution of freshwater features and their connections and identify underlying hydrogeomorphic drivers of these patterns.

24. Simone Fontana[1], Mridul Thomas[1], Francesco Pomati[1]

Individual-based trait diversity indices describe community changes in multidimensional trait space and relate to aquatic ecosystem functioning.

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In the context of understanding and predicting the effects of human-induced environmental change on biodiversity (BD), and the consequences of BD change for

ecosystem functioning, aquatic ecologists face the challenge of understanding the link between individual level variability in functional traits and larger-scale ecosystem processes. Intraspecific trait differences among the phytoplankton have recently become easier to measure due to advances in scanning flow-cytometry, automation of phytoplankton sampling and integration with environmental sensors. This allows measurement of morphological and physiological traits of individual algae with high spatial and temporal resolution. Although individual-based traits can merge inter- and intraspecific variation, the majority of published trait diversity (TD) indices are designed for species mean traits. The uniqueness of automated monitoring data and an individual-based approach require TD to be partially redefined. Accordingly, we propose a set of suitable indices that can perform with large and high-dimensional datasets, and encompass the three components of TD at the individual level (trait richness, evenness and divergence). Since lower level BD at genetic, individual, and population levels largely determines the functionality and resilience of natural populations and communities, we preliminary tested the correlation between these individual-based TD indices and changes in aquatic ecosystem processes.

25. Maxime Fradette[1], Yannick Huot[1], Tara Tapics[1]

High frequency and high resolution planktonic community studies using an automated profiling platform: 1. Environmental variables.

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The Lake Montjoie Plankton Observatory is a cabled automated profiling platform deployed in order to study the ecophysiology of phytoplankton in lakes at high temporal and spatial resolution. Anchored to the lake bottom, the instrumented platform is raised and lowered using an onboard winch. Two of the instruments on the platform allow us to image phytoplankton and zooplankton organisms individually through the water column. The other instruments provide information about key variables of the water column: temperature, dissolve oxygen, conductivity, hyperspectral irradiance, chlorophyll a and others. Thus, time series of in situ data taken at high frequency and high temporal resolution are obtained. Furthermore, local meteorological data stored in our database allow us to link in situ variations of the ecosystem parameters (nutrient concentration, thermocline position, etc.) to meteorological events. These unique observations will allow us to quantitatively relate the plankton successions to environmental conditions. Here, we present preliminary data on the environmental variables obtained from the observatory and meteorology.

26. Marieke A. Frassl[1], Karsten Rinke[1], Louise Bruce[2], Matthew Hipsey[2] and Gideon Gal[3]

Sensitivity of the lake model GLM to meteorological input data

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Lake models are used to assist managers in decision making and to analyse effects of anthropogenic and environmental changes on aquatic water bodies. Over the last years, a new open source one-dimensional lake model, GLM ("The General Lake Model") has been developed. Within a multi-lake comparison project (GLM-MLCP), this hydrodynamic model was applied to several lakes across the world and the parameter sensitivity was tested. This study aims at extending the MLCP study to meteorological input data sensitivity. GLM's sensitivity towards changes in air temperature, relative humidity, wind speed and radiation was tested for a subset of nine MLCP lakes. These nine lakes vary in morphometry, hydrological regime and the climatic region they are located in. Sensitivities are compared between lakes and different lake metrics (epilimnetic and hypolimnetic temperature as well as water column temperature). A sensitivity measure was calculated on each simulation dayfor each lake metric. Sensitivities showed highest values for all lake metrics in response to changes in air temperature. Sensitivity of hypolimnetic temperatures showed the largest variation between lakes.

27. Alexandra B. Gerling[1], Richard G. Browne[2], Paul A. Gantzer[3], Mark H. Mobley[4], John C. Little[2], and Cayelan C. Carey[1]

Whole-ecosystem hypolimnetic oxygenation suppresses internal nutrient loading in a eutrophic reservoir

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Hypolimnetic hypoxia poses a substantial threat to water quality because it can trigger the release of reduced metals and nutrients from lake sediments, thereby stimulating algal growth and altering biogeochemical cycling. Consequently, controlling hypolimnetic hypoxia is crucial for sustaining the ecology of freshwater ecosystems. Here, we present the results of a whole-ecosystem experiment in which we manipulated hypoxia by sequentially injecting water with supersaturated concentrations of oxygen into the hypolimnion of a small, eutrophic drinking water reservoir in summer 2013. Throughout the six-month experiment, thermal stratification was maintained during the alternating oxic (~12 mg/L) and hypoxic (<2 mg/L) hypolimnetic conditions. Oxygenation successfully suppressed the release of reduced iron, manganese, and phosphorus from the sediments. Contrary to expectations, we observed higher sediment oxygen demand during oxic than hypoxic periods. Our experiment demonstrated that hypolimnetic oxygenation can successfully reduce internal nutrient loading. A similar experiment manipulating hypoxia was repeated in summer 2014, specifically focusing on the effects of oxygenation on nitrogen dynamics. We observed that external loading dynamics dominated nutrient fluxes in 2014, despite oxygenation. Consequently, managing external loads of iron,

nitrogen, manganese, and phosphorus must be taken into account when controlling internal nutrient loads via oxygenation.

28. Kathleen D. Hamre[1], Alexandra B. Gerling[1], and Cayelan C. Carey[1]

Effects of hypolimnetic oxygenation on the biology of a eutrophic reservoir

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Hypolimnetic oxygenation is increasingly used to suppress phytoplankton growth in freshwater lakes and reservoirs. However, all studies to date examining the efficacy of oxygenation have focused on the effects of altered redox conditions on internal nutrient or metal loads, and not biological response variables. Here, we examined the effects of oxygenation on the phytoplankton community in Falling Creek Reservoir, a drinking water source and GLEON site located in Vinton, Virginia, USA. This reservoir has a hypolimnetic oxygenation system that was turned sequentially on and off for ~6 week periods during the summer of 2014. We used a Fluoroprobe® fluorometer to quantify the abundances of four different phytoplankton groups: cryptophytes, cyanobacteria, diatoms, and green algae, on ~10 cm interval depth profiles throughout the water column weekly throughout the summer. Surprisingly, hypolimnetic abundances of all four phytoplankton groups increased when the oxygen system was activated. Cryptophytes exhibited the greatest increase of the four taxa, and cyanobacteria increased first in the hypolimnion and then through the entire water column. The Fluoroprobe data provide insight into the effects of dissolved oxygen on phytoplankton community composition and succession, and suggest that hypolimnetic oxygenation may actually stimulate, not decrease, phytoplankton abundance.

29. Bruce R. Hargreaves[1]

High frequency evaporation measurements in a small lake: Testing air temperature data collected at 10 Hzvia a fine-wire thermocouple to quantify sensible heat flux and derived water vapor flux

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Variations in evaporation from lakes and their catchments can influence budgets for water, heat and carbon and these variations have climate change implications on both ecosystem health and water resources. The most accurate methods for quantifying lake evaporation rates are eddy covariance of water vapor flux and budgets for energy and water but methodological issues include expense and spatial heterogeneity in sensor footprints. In this study of a small lake (L. Lacawac) in NE Pennsylvania, USA, a simple surface renewal (SR) method measured sensible heat flux from coherent eddies over the lake surface from which evaporation rate was calculated by combining this heat flux with conventional meteorological measurements (wind speed, air temperature, humidity). The resulting calculations of hourly evaporation rate were compared with evaporation calculated from mass transfer and energy budget

equations (validated with hourly water budget data). This SR method uses a fine-wire thermocouple (FWTC) to measure air temperature at 10 Hz with a Campbell Scientific CR1000 datalogger to characterize eddies rising from the lake surface. A two-month record of continuous 10-Hz air temperature at Z=0.5m was analyzed. Only two published studies of lake evaporation (2009 & 2010) have used or evaluated the FWTCSR method. One goal of the current study is to explore the optimization of several parameters using the complete 10 Hz dataset. Once optimized, the parameters can be used by the CR1000 data logger to generate 2-30 minute averages without saving the raw 10 Hz temperature data.

30. Thomas C. Harmon[1], Sandra R. Villamizar[1], Daniel Conde[2], James Rusak[3], Brian Reid[4], Anna Astorga[4], Gerardo M. Perillo[5], M. Cintia Piccolo[5], Mariana Zilio[6], Silvia Londón[6], Maria I. Velez[7], Natalia Hoyos[8], Jaime H. Escobar[8], and Beverley Wemple[9]

Assessing Freshwater Ecosystem Service Risk over Ecological, Socioeconomic, and Cultural Gradients: Sites, Methodology and Preliminary Results from a Pan-American Study

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[7]University of Regina, Canada
[8]Universidad del Norte, Colombia
[9]University of Vermont, USA

Given the importance of ecosystem services, it is critical that we improve our ability to identify and understand changes in aquatic ecosystems, and translate them to risk of service loss. Furthermore, to inspire changes in human behavior, it is equally critical that we learn to communicate risk, and pose risk mitigation strategies, in a manner acceptable to a broad spectrum of stakeholders. Quantifying the nature and timing of the risk is difficult because (1) we often fail to understand the connection between anthropogenic pressures and the timing and extent of ecosystem changes; and (2) the concept of risk is inherently coupled to human perception, which generally differs with cultural and socio-economic conditions. In this study, we endeavor to assess aquatic ecosystem risks across an international array of six study sites. The challenge is to construct a methodology capable of capturing the marked biogeographical, socioeconomic, and cultural differences among the sites, which include: (1) Muskoka River watershed in humid continental Ontario, Canada; (2) Lower San Joaquin River, an impounded snow-fed river in semi-arid Central California; (3) Cienaga Grande de Santa Marta, a tropical coastal lagoon in Colombia; (4) Senguer River basin in a semi-arid region of Argentina; (5) Laguna de Rocha watershed in humid subtropical Uruguay; and

(6) Palomas Lake complex in oceanic Chilean Patagonia. Results will include a characterization of the experimental gradient over the six sites, an overview of the risk assessment methodology, and preliminary findings for several of the sites.

31. *Amy L. Hetherington[1], Lars G. Rustam[1], Rebecca L. Schneider[1], M. Todd Walter[2], David W. Wolfe[3]*

Ecological forecasting for Oneida Lake: The impacts of climate change and new invasive species on the dynamics of Oneida Lake

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Climate change and invasive species are two of the main drivers impacting the structure and function of lake ecosystems. My research goal is to understand the interactive impacts of climate change and an invasive mussel species using Oneida Lake, a 207 km2 shallow, polymictic lake in Central New York, as a model ecosystem. Oneida Lake is an ideal system due to the wealth of historical climatic, limnological, and ecological data. My objectives focus on the interactions of water temperature increases and thermal stratification associated with climate change and the invasive quagga mussel. Quagga mussels are ecosystem engineers that now dominate the benthic habitat of Oneida Lake and many other lakes in the northeastern United States. Hypothesized effects include decreases in spring diatom blooms and zooplankton and increases in larval fish mortality and submerged aquatic vegetation. However, climate change, through increased water column temperatures and thermal stratification, will potentially mediate the effects of quagga mussels as the mussels can be affected by decreases in water column access and increases in oxygen depletion. Forecasting effects of this invasive species, in the midst of climate change, requires a predictive model that couples ecology and hydrodynamics to inform sound management decisions of lake ecosystems.

32. *Hunter P.D.[1], Tyler, A.N.[1], Groom, S.[2], Dall'Olmo, G.[2], Tilstone, S.[2], Martinez-Vicente, V.[2], Merchant, C.M.[3], MacCallum, S.[3], Cutler, M.[4], Rowan, J.[4], Dawson, T.[4], Maberley, S.C.[5], Carvalho, L.[6], Elliot, J.A.[6], Thackery, S.[6], Miller, C.A.[7] and Scott. E.M.[7]*

GloboLakes: A global observatory of lake responses to environmental change

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The world's freshwater ecosystems are vital components of the global biosphere, yet are vulnerable to climate and other human-induced change. There is increasing recognition that lakes play an important role in global biogeochemical cycling and provide key ecosystem services. However, our understanding of how lakes respond to environmental change at a global scale, and how this impacts on their status and function, is hampered by limited information on their chemical, physical and ecological condition. There are estimated to be 117 million lakes globally, of which over 17,000 are greater than 10 km^2 in surface area. These sheer numbers have militated against the systematic study of lake ecosystems.

GloboLakes is a five-year research programme investigating the state of lakes and their response to climatic and other environmental drivers of change through the realisation of a near-real time satellite based observatory with archive data processing to produce a ~20-year time series of observed ecological parameters and lake temperature for over 1000 lakes globally. This will be supported by linked auxiliary data on catchment land-use and meteorological forcing. The ability to monitor a large number of lakes consistently at high frequency and globally will facilitate a paradigm shift in our understanding of how lakes respond to environmental change at different spatial and temporal scales. This poster will introduce the GloboLakes project and outline its scientific ambitions for the next 5 years.

33. Peter Isles[1,2], Jason Stockwell[1], Courtney Giles[2], Yaoyang Xu[2], Andrew Schroth[2,3]

Quantifying the effects of cyanobacterial buoyancy regulation on lake metabolism using high-frequency data

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Buoyancy regulation by cyanobacteria in eutrophic shallow lakes may allow higher levels of primary production than would be possible with a population distributed evenly throughout the water column. By rising to the surface during the day and descending to deeper waters at night, cyanobacteria can alleviate light limitation while preserving access to benthic nutrients. This process has consequences for the balance of ecosystem metabolism across depths because daytime oxygen production will be concentrated in surface waters, whereas nighttime respiration will disproportionately affect deeper waters. These dynamics may also have consequences for the accessibility of sediment stores of phosphorus, which is influenced by oxygen concentrations, and may lead to feedbacks that contribute to the maintenance or collapse of bloom conditions. Here we investigate the effects of cyanobacterial buoyancy regulation on lake metabolism using two complimentary approaches utilizing high-temporal-resolution data from a monitoring buoy moored in Missisquoi Bay, Lake Champlain, VT. Our analyses highlight the interacting roles of buoyancy regulation, light and wind in contributing to the progression of summer cyanobacterial blooms and fish-kill events.

34. Lorraine L. JANUS[1], James D. Mayfield[2], Karen E.B. Moore[2] Richard Van Dreaso [2], Donald C. Pierson[2]

Trophic Response of Catskill and Delaware Reservoirs compared to OECD Regressions

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The trophic response of NYC reservoirs under changing environmental conditions and increasing watershed protection and remediation over the past 25 years is examined. The standard regressions developed by the Organization for Economic Cooperation and Development (OECD) Cooperative Program on Eutrophication provide a context for comparison of reservoir response. The OECD Standard Regression Lines were developed from over 100 northern temperate zone lakes. The Canadian Contribution test case, examined 7 lake regions across Canada to test the standard regressions. DEP reservoirs provide a second independent test case. NYC reservoirs vary in their trophic responses to nutrients according to different meteorological, physical, and chemical factors. Given the wide variety of responses possible at a given nutrient level, it is essential to understand the causes of such variation to predict the effects of environmental changes on water quality. We plotted reservoir data on the standard OECD regression lines (that represent a large population of northern temperate lakes) and then examined the residuals to determine what factors can cause departures from the standard relationships. This analysis places our data in context and reveals important differences in reservoir responses to identify major environmental drivers of water quality that will be useful in water quality management. The diagnostic use of standard regression lines also highlights factors that need to be considered in future modeling to reduce prediction uncertainty.

35. Jean-Philippe Jenny[1], Pierre Francus[1], Alexandre Normandeau[2] and Marie Perga[3]

Titre: Identifying GLEON's sites recordingannually-resolved sediments over the last centuries (or millennia)

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Sediments: they are present in all lakes, they are available at any time, and they contain continuous times series of past ecological conditions, sometimes with seasonal-to-annual resolution. Such precious archives are ideal to extend time series analysis of environmental changes and forcings further in the past. Of these sediments, varves (annually laminated sediments) are exceptional archives as they integrate environmental conditions over a year, hence providing past reconstructions with annual resolution. Varves can form in lakes of almost all latitudes and in all continents but their preservation occurs in seasonally low oxygen environments, as in meromictic and eutrophicated lakes. Strategies coupling monitoring and varve records have been tested successfully in 3 GLEON's sites (Bourget, Annecy, Geneva) through the IPERRETRO program (2009-2013). In 2014, in order to strengthen connections between

limnologists and paleolimnologists, the Varve working Group of PAGES has compiled published records of varve sediments from more than 500 lakes distributed on six continents. We used this database to assess the global distribution of recent high-resolved sediments and to identify sites common to GLEON and PAGES where long-time series of records are available. Our results show that a total of 9 varved lakes are already studied by the GELON. We also show that the number of lakes recording varves has been extending worldwide, since the mid-nineteenth century (indicating the growing effects of Human activities on global lake hypoxia dynamic). We are now confident that proven benefits of interdisciplinarity and the recent knowledge on varve distribution in the world could encourage future selection of some varved lakes throughout the GLEON's processes.

36. *Eric O. Johnson*[1]

Software tool design for on-site data collection with active validation and automatic remote storage

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To improve upon paper based data collection, a new software tool was developed and is being used by Craig Williamson's team. We designed this to go beyond the typical data collection methods by providing interactive help for data collectors, using modern layout design principles and integrating the tool into the overall research data workflow. Collected data is automatically uploaded and compiled into a single database to simplify queries and analysis.

- Data entry layout is optimized based on modern Human Computer Interaction (HCI) research.
- Data entry is interactive with prompts, guidance and dynamic color coding to help students and others collect accurate data.
- As data is entered, it is automatically validated. Errors are immediately reported to the data collector so they can be corrected while the data is fresh.
- Data validation rules adjust to match the site and conditions being observed and can be updated remotely by the Principal Investigator as needed.
- Data is automatically uploaded to a central server with metadata, ready for analysis.
- Data can be extracted using standard SQL queries into open formats such as csv.
- Sonde data files are connected to the manually collected readings in the central database.
- Metadata was designed with the Morpho program and Ecological Metadata Language in mind for broader sharing.

37. Medina O. Kadiri[1]*, Osasere A. Omoruyi*[1]

Water quality assessment of a man-made community lake in Southern Nigeria

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Ozomu Lake, latitude 060 15′ 01.7″ - 060 15′ 0.19″ N and longitude 0050 27′ 07.2″ - 0050 27′ 07.4″ is situated in the wetland area of a tropical rain forest, at Ozomu settlement in Igbobi community in Benin, Nigeria, West Africa. The lake is utilized by the community as a source of water supply for domestic purposes. Water quality assessment of Ozomu lake was carried out between January and June 2013. The lake is turbid, acidic, (pH 5.84), with moderate nutrient levels-mean conductivity 62.8 µS/cm, phosphate 0.72 mg/l, nitrate 0.26 mg/l. Phytoplankton flora (429) taxa comprising four divisions namely Chrysophyta (62.91%), Euglenophyta (28.44%), Chlorophyta (11.89%) and Cyanobacteria (6.06%).The composition is dominated by diatoms notably *Navicula* and *Pinnularia.* The green algae were mainly desmids, in particular *Closterium* and cyanobacteria were *Anabaena* and *Oscillatoria*. Palmer's pollution tolerant algal species were present in the lake.

38. Kangro, K.[1,2], Vilbaste, S.[1], Laas, A.[1]

Phytoplankton development in combination with high frequency temperature and oxygen measurements in hypertrophic lake Verevi, Estonia.

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Lake Verevi is a small relatively deep lake, which become hypertrophic due to irregular discharge of urban wastewater during seventies. Heavy blooms of Planktothrix agardhii were recorded in eighties, but nowadays water is relatively clear with no cyanobacterial blooms. Development of phytoplankton community was followed from ice break-up in late April until early June. Our initial goal was to monitor temperature, oxygen and phytoplankton dynamics during the spring mixing period and onset of stratification, but since the lake did not mix this spring, we followed changes in phytoplankton community in stratified conditions. Water temperature in surface layer increased from 5.5°C to > 20°C within three weeks due to exceptionally warm weather. Oxygen content was high below the surface and at the peak of phytoplankton (up to 20.4 mg/l), anaerobic zone began from 2.5 m in April and lowered up to 4.5 m in June. Phytoplankton total biomass peaked in the middle of May, being lower just below the surface (5 g/m3) and higher in deeper layers (up to 7 g/m3). After ice-break Chlamydomonas sp. dominated, being abundant above 2 meters (with biomass up to 4 g/m3). In early May cryptophytes and diatoms become dominant. Diatoms peaked (biomass 4.2 g/m3) in the middle of May firstly near surface and then deeper, with rich community (up to 29 species). Chrysophytes were nearly absent in deep water and abundant below the surface with a peak in mid-May. The biomass of dinophytes rose at the end of May and beginning of July.

39. Patrick T. Kelly[1], Alexandra Searle[1], and Stuart E. Jones[1]

Habitat use governed by predation risk and resource quality in a heterogeneous environment

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Vertical migration causes differences in lake habitat use by zooplankton, and is mediated by the presence of fish and invertebrate predators. Subsequently, the amplitude of the migration distances is reduced by darker water, as it offers a natural predator refuge. Resource quality throughout the water column is often variable, with metalimnetic resources of greater quality than epilimnetic resources in terms of both carbon-to-phosphorus ratios and the concentration of essential fatty acids. Using a survey of lakes that span gradients of predator densities and water color, we measured epilimnetic and metalimnetic resource quality, zooplankton biomass, and zooplankton vertical habitat use across lakes. Our results suggest a difference in resource quality between habitats that may have implications for zooplankton production. We also present results of a modeling exercise to evaluate fitness implications of habitat use mediated by vertical migration through a heterogeneous environment. Our results suggest the costs of migration are likely influenced by resource quality differences among habitats in addition to temperature, migration distance, and predation probability.

40. Michael Kehoe[1]

Seasonal and decadal dynamics in long term algal and limnological data set

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Algal blooms are a common problem in the Canadian prairies, affecting recreational uses, lake ecology, and having a major impact on drinking water treatment processes. In this study, we show how variation in climate and hydrology, and the interaction of these with catchment characteristics has influenced a Canadian lake to switch to a high N:P ratio which is dominated by N-fixing cyanobacteria and now experiences annual problems with taste and odour issues. We assess 30 years of biogeochemical data from a eutrophic, shallow, polymictic lake which serves as a critical regional drinking water supply. This long-term data, collected by the water treatment plant shows that the lake has undergone oscillating changes in important water quality parameters. Threshold odour number has varied 100-fold through the data record, with a significant increase occurring in 1999, and persisting for more than 10 years. This change in odour was preceded by a change in mean N:P ratio from ~16:1 to >~20:1 and coincided with an increase in overall productivity and filamentous cyanobacteria.

41. Alfred Theodore N.K Kpodonu[1], and David P. Hamilton[1]

Phosphorus retention in sediments of a deep temperate oligotrophic lake is related to concentrations of cyanobacteria pigments

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Lacustrine sediments contain a great wealth of data on biogeochemical and limnological processes of historical importance which can be used to interpret natural ecosystem dynamics, and climatic and anthropogenic impacts. In this study, we used this information to understand the relationship between phosphorus (P) retention and paleo-pigments in lake sediments and to assist with understanding historical trophic

state of a deep, oligotrophic lake. A 49-cm sediment core was retrieved from Lake Okataina in the North Island, New Zealand and its depositional history was dated using ^{210}Pb. Amongst New Zealand lakes, Okataina may be considered close to a "reference" lake, with 89% native forest and without a significant change in its land-use in the past c. 100 years. However, possible perturbations to the lake during this time may be due to expanding populations of invasive terrestrial mammals, which may influence catchment vegetation density and type, as well as introduction of trout. Sequential extraction of P was carried out from sediment core layers corresponding to different sediment deposition time. High Performance Liquid Chromatography (HPLC) was also carried out to identify and quantify a number of paleo-pigments. Biologically refractory P species made up 90.8% of the total phosphorus while redox sensitive P constituted 9.2%. Using Pearson-Moment correlation, refractory P showed a strong positive correlation ($p<0.001$) with the cyanobacteria pigments canthaxanthin and myxoxanthophyll ($r = 0.80$ and $r = 0.80$ respectively). Biologically refractory P showed a negative relationship ($p<0.01$) with lutein, and chlorophyll b proxies for green algae ($r = 0.78$ and $r = 0.62$). Redox sensitive P correlated positively with lutein and chlorophyll b ($r = 0.86$ and $r = 0.93$) but not significantly with cyanobacteria pigments.

42. Bomchul Kim[1], Youngsoon Choi[1], Sungmin Jung[1], Jaesung Eom[1], Jihye Choi[1]

Effect of rain on phytoplankton density and turbidity in streams and reservoirs of Korea; monitoring by sensors

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Heavy rains are commonly associated with the increase of turbidity in streams of both agricultural area and urban area. Because turbidity, dissolved oxygen, and phytoplankton density changes drastically during rain events, high frequency monitoring is essential in Korean streams. Water monitoring sensors were installed in a reservoir (Lake Soyang) and two urban streams for monitoring the short term variation of ecosystem. In the reservoir phytoplankton density changed in a daily time scale according to the change of inorganic turbidity after rain. Clay particles were attached at the cell surface of phytoplankton which caused increase of settling velocity and subsequent rapid decrease of phytoplankton density. In urban streams turbidity increased drastically in hourly time scale at the early stage of a rain event, which were associated with the decrease of dissolved oxygen. In the fish survival test all fish died in the turbid urban stream water of first flush. Therefore the urban stream sites were evaluated through the high frequency monitoring as impaired habitats which cannot support healthy fish community. It shows high frequency monitoring is essential for the assessment of the ecological health of urban streams.

43. Benjamin M. Kraemer[1], Orlane Anneville[2], Sudeep Chandra[3], Margaret Dix[4], Esko Kuusisto[5], David M. Livingstone[6], Geoffrey Schladow[7], Eugene Silow[8], Lewis M. Sitoki[9], Yvonne Vadeboncoeur[10], Peter B. McIntyre[1]

Lake geomorphology and baseline temperature control stratification responses to climate change

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[10]Department of Biology, Wright State University, Dayton, OH, USA

Lake warming is affecting lake mixing dynamics globally with potential impacts on the ecosystem services that lakes provide to society. Lake surface warming rates are fastest at high latitude, but global patterns in surface warming rates may not predict global patterns in lake stratification responses to climate change. Here we compile temperature data from 24 lakes around the world and show that lake warming rates are poor predictors of long term trends (1970-2010) in lake stratification indexes. We use model selection techniques to show that baseline temperatures and lake geomorphology characteristics are better predictors of long term trends in lake mixing indexes. Deep and voluminous lakes with high baseline temperatures have experienced the largest changes in lake stratification indexes even though they tend to have relatively slow volume-weighted warming rates. This work suggests that the impact of climate change on lake stratification may be greatest in the tropics where biodiversity is higher and where minimal investments are made in lake management.

44. Alo Laas[1], Tanel Altement[1], Peeter Nõges[1]

Early spring whole lake metabolism in a stratified lake

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Changes in dissolved oxygen (DO) can be used to determine metabolic rates in lakes. Most lake buoys have only one DO sensor placed in the upper mixed layer (epilimnion) of the lake that cannot give adequate data for calculating whole lake metabolism as it leads to inaccurate metabolic rate estimates for deeper layers. In this study we compare lake metabolic rates within three depth layers (epi-, meta- and hypolimnion) in the stratified Lake Verevi. Lake Verevi is a small and relatively deep lake with low water exchange. Due to high relative depth (the ratio of maximum depth as a percentage of the mean diameter of the lake on the surface), the water column does not mix easily. The lake is thermally sharply stratified and strong gradients of chemical substances occur during summer. The lake is usually dimictic, but in some years the spring overturn

remains incomplete even at homothermal conditions, which adds some meromictic features to the lake. In the early spring 2013, the mean gross primary production (GPP) in the epilimnion was 122 (all values in µmol O2 m^{-3} d^{-1}), the highest value (125) occurred in the metalimnion while there was no GPP in the hypolimnion of the lake resulting in a low GPP value (56) for the whole water column. Respiration (R) was also highest in the metalimnion, and varied from 2 to 308 within the whole water column. The mean net ecosystem production (NEP) was 47 in the epilimnion and 40 in the whole water column.

45. Jean-François Lapierre[1,2], Paul Del Giorgio [1]

Hydrological, biological and chemical drivers of the color of DOC across boreal lakes and rivers

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In many temperate and boreal freshwater environments, dissolved organic carbon (DOC) and colored dissolved organic matter (CDOM) are almost considered as synonymous because most of the DOC pool originates from the surrounding landscape and is typically colored. While this may apply across rather homogenous sets of aquatic environments, the situation is much more complex across large and diverse landscapes where chemical, biological and hydrological properties with known effects on the color of DOC (i-e the CDOM:DOC ratio) vary in different directions. We found that the absorption of light by CDOM was, intuitively, linked case to the concentration of DOC, but that extrinsic chemical (iron, pH) and intrinsic compositional (fluorescence properties) variables were also important drivers of the color of DOC at that scale: the CDOM to DOC ratio varied by more than an order of magnitude across over 500 lakes and rivers that we sampled over the last five years. These presumably causal drivers of the color of DOC were underlain by cross-regional and cross-system patterns in hydrology (water stable isotopes) and system trophic status (Chla: CDOM) that suggest a cumulative loss of color for DOC as it circulates through continental watersheds, whereas an additional layer of autochthonous, uncolored DOC is added in productive systems. These findings show the importance of considering the hydrological and environmental contexts when considering the use of CDOM as a proxy of DOC, or conversely, the contribution of DOC to aquatic processes and light attenuation in the water column as the environment keeps changing.

46. Taylor H. Leach[1], Joseph D. Warren[2], Jennifer A. Brentrup[1] and Craig E. Williamson[1]

High-resolution acoustic and environmental data provide insight into vertical distributions and diel migrations of zooplankton

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Pelagic zooplankton play a critical role in freshwater ecosystems that is largely dependent upon their spatial distribution and abundance. Zooplankton are highly responsive to environmental conditions that can vary rapidly in space and time and may provide excellent indicators of environmental change. High frequency sensor data may be particularly important to the effective resolution of ecological processes involving zooplankton as their distribution and abundance vary on spatial and temporal scales that are much finer than can be observed with traditional zooplankton sampling methods. Acoustic backscatter data (in conjunction with net sampling) can provide vertical and temporal resolution, as well as biomass estimates of zooplankton on scales similar to many of the high-resolution sensors included in the GLEON buoy network. Here, we couple high frequency environmental data with zooplankton vertical distributions. We examine how changes in environmental variables such as temperature, light, dissolved oxygen and chlorophyll fluorescence drive the migration of zooplankton across vertical habitat gradients. This work demonstrates how fine-scale zooplankton distributions relate to rapidly changing external drivers.

47. John D. LENTERS[1], Craig George[2], Geoff Carroll[3], Brittany L. Potter[1], Kenneth M. Hinkel[4], Christopher D. Arp[5], Karen E. Frey[6]

Long-term trends in ice formation and breakup dates for a thermokarst lake in Barrow, Alaska

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More than one fourth of the world's lakes are located in the Arctic, where climate is changing rapidly, and permafrost is becoming degraded. The Arctic Coastal Plain of northern Alaska has an especially high density of thermokarst lakes, with roughly 40% of the landscape being comprised of lakes or drained lake basins. This highlights the need for long-term lake monitoring through programs such as NSF's Arctic Observing Network. In recognition of this, a collaborative project was begun in 2012 to establish a "Circum-Arctic Lakes Observation Network (CALON)," which includes extensive monitoring of nearly 60 lakes in northern Alaska. CALON team members also interact with local residents in Arctic communities to identify additional sources of information on thermokarst lakes. One such community is Barrow, Alaska, where long-term observations of ice formation and breakup dates for an inland lake (Isatkoak Lagoon) have been made since 1987. The lake ice record shows a clear trend toward later freeze dates (~7.7 days per decade) and earlier breakup dates (~3.4 days per decade), with an overall decline in ice duration of about 28 days over the 25-year period (1987-2012). Similar delays in freeze-up dates since 1999 (~5 days per decade) have also been noted for a local fishing site (Ikroagvik Lake), based on the ability to access the lake in autumn to set and retrieve fishnets. Here, we investigate the various climatic drivers of the observed

decline in lake ice duration, as well as its connection to similar declines in Arctic sea ice.

48. Sally MACINTYRE[1], A. T. Crowe, J. H. Amaral, L. Arneborg , A. Andersson, D. Bastviken, B. R. Forsberg, M. Galfalk, J. Karlsson, J. M. Melack, E. Podgrajsek , A. O. Rutgersson, J. Tota, and E. W. Tedford

Turbulence at the Air-Water Interface in Lakes of Different Sizes: Consequences for Gas Transfer Coefficients

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We measured turbulence with an acoustic Doppler velocimeter (ADV) and/or a temperature-gradient microstructure profiler and obtained correlative time series measurements of meteorology and water column temperature in an 800 m^2 arctic pond, a 1 ha boreal lake, and a tropical reservoir. Turbulence measurements with both instruments corroborated those calculated from similarity scaling in the boreal lake. Within the arctic pond, dissipation rates (ε) obtained with the ADV agreed with those from similarity scaling when winds exceeded ~1.5 m/s with a greater frequency of measurable dissipation rates when surface waves were present. ε exceeded predictions from similarity scaling with light winds and rain. ε in the tropical reservoir reached and often exceeded 10^{-6} m^2 s^{-3} in the upper meter under heating with light winds and decreased by an order of magnitude with cooling or rainfall. Under cooling, ε was an order of magnitude higher in the upper 25 cm than in the water column below. Gas transfer coefficients calculated from concurrent measurements of greenhouse gas fluxes with floating chambers and the surface renewal model using the estimates of ε were in agreement. These results support the predictions of Monin-Obuhov similarity scaling in that shear dominates turbulence production near the air-water interface under heating and cooling, illustrate temporal variability in turbulence production in small water bodies due to intermittent wind, indicate that shear and associated turbulence can be intensified in shallow mixing layers under heating with light winds, and illustrate the utility of similarity scaling for predicting gas transfer coefficients.

49. Iwaki Maho[1], Michio Kumagai[2]

Lake Biwa water level analysis using multiple time scale analysis method - main cause of long-term decline

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Water level data measured at a station in Lake Biwa from 1971 to 2010 shows the decline of about 25 cm during last four decades. Each phenomenon that may change the water level of a lake has its own characteristic time scale. In this presentation, we try to classify the water level with the various fluctuations in the lake using multiple time scale analysis method (MTSAM) and discuss the reason of this decline. First we analyzed meteorological data and found the annual total rainfall has not changed so

much. In the northern catchment area, major winter rainfall is due to snow. The snow water equivalent, however, showed a tendency of decreasing. The total amount of discharge from Lake Biwa has also decreased. Calculating the water mass balance of rainfall, outflow and snowfall, it could be suggested that the decline of water level was caused by evaporation increase or groundwater decrease.

50. Mark J. McCarthy[1]

Nutrients and harmful algae blooms: why do we ignore nitrogen?

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The phosphorus limitation paradigm has dominated eutrophication research and management in freshwater systems for decades. This paradigm, however, is based on results from one lake, which have been interpreted to claim that nitrogen control in catchments is futile. The role of nitrogen has been repeatedly dismissed in high-profile journals and plenaries at international meetings. As a result, there are significant gaps in our understanding of the causes and maintenance of eutrophication in lakes. Recent advances in nitrogen and cyanobacteria dynamics refute the basis of the phosphorus limitation paradigm. For example, studies have shown that nitrogen mobilizes phosphorus in sediments, intensifies eutrophication and cyanobacteria toxicity in naturally phosphorus-rich lakes, and leads to loss of macrophytes. The composition, concentrations, and turnover rates of different nitrogen forms also play the primary role in determining phytoplankton community structure and cyanobacteria toxicity. The phosphorus limitation paradigm fails to explain numerous cases where phosphorus control has not reduced eutrophication, does not acknowledge that biogeochemical mechanisms favor nitrogen limitation or that nitrogen limitation is not easily reversed, and most importantly, ignores the proliferation of toxic, non-nitrogen-fixing cyanobacteria. Failure to control nitrogen in inland catchments also has ramifications for downstream environments (e.g., Gulf of Mexico). These failures, recent advances in understanding cyanobacteria biochemistry and eutrophication dynamics, and new interpretations of the results used to generate and perpetuate the phosphorus limitation paradigm demand that eutrophication research and nutrient management proceed using a more modern approach. This contemporary strategy evaluates systems individually and considers both nitrogen and phosphorus management.

51. Pille Meinson[1]*, Alo Laas*[1]*, Peeter Nõges*[1]

Continuous and high-frequency measurements in limnology

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Over the past 15 years, high-frequency measurements have been increasingly used in various fields of limnology. This new technology offers scientist a chance to investigate processes in lakes at scales that was not possible earlier and places where regular

sampling would be complicated or even dangerous. This has given a strong impetus to the enlargement of monitoring and early warning systems, enabled capturing the effects of episodic events and highly dynamic processes, and has provided a basis for developing new methods for studying lake metabolism and budgets. In this study, based on a literature record from the last 15 years, we exemplify the different purposes for which high-frequency measurements have been successfully applied in limnological research and water management.

52. Mathis L. Messager[1], Bernhard Lehner[2], Guenther Grill[2]

HydroLAKE: a new global dataset of lake areas and volumes

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Lakes are key components of hydrological, biogeochemical, and ecological systems on a variety of spatial scales. Knowledge about their volume is crucial to the understanding of their properties and interactions with other elements in these systems. However, empirical data are scarce either paper based or completely unavailable with little to no consistency across regions. The aim of this study was to develop a geostatistical model within a Geographic Information System (GIS) to estimate the volume of individual lakes on a global scale, based on existing empirical lake volume data and global elevation data. After testing a wide variety of approaches with different degrees of complexity and computational requirements on nearly 6,000 lakes, we found that an intuitive approach for interpolating lake bathymetry, accounting for local topographic characteristics of shores, performed better than previous methods documented in the literature, and could be applied on the global scale with consistency after statistical adjustment with empirical data. The Mean Absolute Percentage Error (MAPE) of the predicted lake volumes was 60%. The product of the application of this model, an estimate of lake volumes and surface areas of unprecedented quality for over one million lakes, called HydroLAKE, will provide crucial parameters for the estimation of water availability for domestic, industrial, and irrigation uses, as well as for modeling fundamental phenomena in lakes, mostly regulated by their residence time, such as the concentration of pollutants and nutrients in their water or their heat budget.

53. Karen E.B. Moore[1] and James D. Mayfield[1]

Applying a Novel Approach to the Analysis of Long-Term Water Quality Data

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Years of investment in watershed water quality monitoring have informed policy and planning efforts for New York City's water supply. We took advantage of the wealth of accumulated streamflow and water quality data for the West Branch of the Delaware River and other long-term monitoring sites to apply the "Weighted Regressions on

Time, Discharge, and Season" approach described by Hirsch et al. (2010) to gain insights into the long-term record and look for new revelations in the data. Software tools including EGRET (Exploration and Graphics for RivEr Trends) and dataRetrieval, R packages developed by Hirsch and others at the U.S. Geological Survey, are facilitating the process, and we believe there is great value in re-examining the long-term record as the record builds, particularly in the context of severe storms and climate change.

54. Nicholas Myers[1], Gabriella Pinter[2], Istvan Lauko[2], Todd Miller[1]

Cyanobacteria bloom model dynamics and calibration using parameter selection techniques

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Harmful algal blooms, especially those related to *Microcystis*, can be toxic to humans and freshwater biota. Managing this growing problem will depend upon the existence of accurate modeling approaches. In this work, a model described by a system of nonlinear integro-partial differential equations (including convective and diffusive terms and non-local light-limited growth) is modified to represent the ecosystem of a lake in central Wisconsin. The model developed for predicting *Microcystis* algal blooms incorporates light intensity, nutrient densities, water column mixing, and interspecies competition. Parameter selection techniques tested include global sensitivity measures and Bayesian methods. In addition, these techniques examine the importance of individual parameters to the dynamics of the system and their relationships to each other.

55. Emily R. Nodine[1], Orlane Anneville[2], Bastiaan Ibelings[3], and Jason D. Stockwell[1]

Storm-Blitz: The Impacts of Storms on Phytoplankton Communities

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[3]Forel Institut, University of Geneva, Switzerland

"Storm-Blitz" is part of a research series of the Theory Working Group (TTG) of GLEON related to the effects of physical disturbances and water column stability on plankton communities. Phytoplankton traits are associated with stable and mixed water column conditions, demonstrating the main role of thermal stratification in steering phytoplankton composition and succession. However, phytoplankton community organization also depends on the longevity of thermal stability. Environmental disturbances such as floods, storms or episodes of increased wind mixing can abruptly alter succession, returning the community to a prior successional stage. Consequently, extreme meteorological events that modify a lake's physical and chemical habitat are expected to shape changes in phytoplankton composition. Storm-Blitz objectives are to

analyze datasets from diverse lakes to (1) test if and under what conditions storms impact phytoplankton assemblages, in terms of diversity, species composition, and morpho-functional traits, and (2) characterize the changes in the phytoplankton community to address mechanisms that lead to new communities. The results should offer excellent examples to question the sensitivity of aquatic ecosystems to extreme weather events.

56. Samantha K. OLIVER[1], Emily H. Stanley[1], C. Emi Fergus[2], John Downing[3], Caren Scott[2], Patricia A. Soranno[2], Tyler Wagner[4], Katherine Webster[5], and Luke Winslow[1]

Prediction of lake depth across a 17-state region in the U.S.

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Lake basin morphology influences physical, biological and chemical processes of lakes. While satellite technology has greatly improved information on lake number and area, predictions of lake depth are elusive particularly over large spatial scales. Current predictive models of lake depth that use surrounding topography and area explain less than 40% of the variability in depth, and do not for the potential interaction between terrain and surface area. Additionally, a predictive model of lake depth using geomorphology has not been made for U.S. lakes. Using a dataset of 6,000 lakes across a 17-state region, we used linear mixed modeling to allow for the relationship between surface area and depth to vary by region. The top-ranked model (by AIC) allowed model parameters to vary regionally and showed the relationship between area and lake depth co-varied with surrounding terrain steepness. The more complex model reduced root-mean-square deviation by 0.8 m relative to a simple geomorphology model. Additionally, we identified that the model performs poorly in flat relative to steep terrain (R^2= 0.13 and 0.48 for the flattest and steepest 10% of lakes, respectively) suggesting that alternative approaches should be explored to predict lake depth in flat regions.

57. Melanie M. Perello[1], and Lisa Doner[1]

Assessing the impacts of past and current climate on water quality in Northern New England lakes using sediment analyses and monitoring

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Changing climate is expected to significantly affect our water resources, impacting the hydrological processes and the quality of these resources. Due to the high heat capacity of water, and their large water volume, lakes are particularly susceptible to climate change, but the relationships between climate forcing and water quality is

poorly constrained. To better understand the effects of climate change on lake systems, this study assesses the relationship between climate and water quality in Northern New England lakes. Our study combines monitoring of water temperature with an in situ mooring and water quality sampling with lake sediment analysis. We generated a time series of water conditions including temperature, conductivity, dissolved oxygen, major ions and phosphorus versus the depth of the water-column in lakes Ossipee and Squam, NH in every season. Lake water conditions were also compared with local weather stations and hydrological records to constrain lake responses to short-term meteorological conditions and events. The time series is expanded over long timescales (determined with Lead-210 sediment dating), including intervals prior to European settlement, through sediment analyses with a focus on diatom community assemblages and geochemistry. The project informs local community stakeholders, including lake management associations and conservation groups, on the potential implications of changing climate on their respective lakes and encouraging proactive responses to address this issue.

58. Vanesa L. Perillo[1], Courtney Balling[1], Donald S. Ross[1], and Beverley Wemple[2]

Movement and release of phosphorus from stream bank soils into Lake Champlain

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The growth of algal blooms is limited by the amount of bioavailable phosphorus (P) present in lakes and other freshwater bodies. This nutrient is released into the streams feeding a lake by soil erosion and anthropogenic activities such as farming and fertilization. Lake Champlain (located in between the states of Vermont and New York in the United States and the province of Québec in Canada) is known to have algae blooms between June and September. Soil samples were collected in the Missisquoi Bay Watershed (MBW) and Mad River Watershed (MRW) (summers 2012-2013) in corn and hay fields, and in the riparian buffer and stream bank of each site. Preliminary results show that soils sampled in the MBW have a higher amount of total and available P at near-surface depths (0-15 and 15-30 cm), due to more intensive agricultural practices, than MRW. While potentially presenting a higher risk of available P runoff in extreme weather events, the presence of a riparian buffer could be protecting the stream from P runoff. Since stream bank erosion is a not-sufficiently characterized source of P to the lake, we will next study the delivery mechanisms of bioavailable P originating from this type of erosion. Sampling and testing will be employed to determine the organic P fraction and its speciation, the effect of stream buffer width and land-use on P fractions in stream bank soils and the transformation rate of organic P to inorganic P when this soil is submerged. P transport mechanisms will be examined by flowpath modeling.

59. Patricia PERNICA[1], Rebecca North[1] and Helen Baulch[1]

A method to estimate mixing depth under ice in mid-latitude lakes

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For a mid-latitude lake, there is currently no well-defined method for identifying the mixed layer depth under ice cover. The current definition is based on a typical thermal structure of a lake during the summer. During the summer, the mixed layer is a nearly isothermal layer that extends from the surface to the thermocline; a region of rapidly decreasing temperature. These clear bounds on the mixed layer allow for the use of a temperature gradient cutoff to define the vertical extent of the mixed layer. During winter, this thermal structure is not present and there is often no easily visible isothermal layer. The water next to the underside of the ice is close to 0°C and increases with depth towards the temperature of maximum density, approximately 4°C. Instead of a temperature gradient cutoff, we define a mixed layer depth as the near surface region of the water column that is actively mixing. Under ice the primary source of energy to drive mixing is via incoming solar radiation. The warming near the surface creates a local increase in density resulting in a gravitational instability causing convective mixing. Field measurements of radiation intensity and temperature profiles through the water column were taken monthly from three Saskatchewan lakes during the winter of 2013.The mixed layer depth is defined here as the depth at which the intensity of solar radiation required for mixing, balances the strength of density stratification that inhibits mixing. The change in mixed layer depth throughout the winter season is discussed in terms of this energy balance.

60. Rachel M. PILLA[1], Craig. E. Williamson[1], Jing Zhang[2], William H. Renwick[3], Jennifer A. Brentrup[1], Robyn Smyth[4], John D. Lenters[5], Benjamin Felzer[6], and Lesley B. Knoll[7]

Thermal sentinel responses of lakes to regional climate and teleconnections

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Lake ecosystems are among the most effective sensors of climate change because they exhibit strong responses to both precipitation and thermal components of climate change. Two small temperate lakes in northeastern Pennsylvania, USA, have exhibited surface warming and strengthened thermal stratification during mid-July over the past 26 years, despite a lack of significant increasing trends in regional air temperatures. This study examined the response of six thermal metrics in these lakes during a period close to maximum summer stratification (two measurements of temperature, two of depth, and two of stratification) to 13 climate variables ranging from local

meteorological variables to compound variables and teleconnections. Thermal stratification metrics generally exhibited the strongest responses in both lakes. On average air temperature-related variables, hydrology-related variables, and teleconnection indices provided similar explanatory power for thermal response metrics. Seasonal periods of climate variables were identified as providing more explanatory power than annual averages. Air temperature-related climate variables increased most in explanatory power when considering these peak time periods vs. annual averages, compared to hydrology-related variables and teleconnections, which already had high explanatory power when considering annual averages. Combining climate variables from peak time periods into multiple regression models explained 89% of the variability in thermal stratification in the clearer of the two lakes. These changes in thermal structure are largely related to increased inputs of dissolved organic carbon (DOC) and consequent changes in water transparency associated with changes in precipitation, in addition to direct lake warming due to heat transfer, with potentially important ecological consequences.

61. Amina Pollard[1]

Broad-scale patterns of biological, chemical, physical, and recreational condition and change in lakes: an example from the US National Lakes Assessment

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The protection and management of aquatic systems benefits from periodic monitoring that can inform resource managers and the public about the current status of and changes in the systems of interest. The US National Lakes Assessment (NLA), one of the National Aquatic Resource Surveys, is a program designed to address these questions at a national scale. NLA uses a probability-based design to represent the condition of the population of lakes in the conterminous United States. We use consistent collection and analytical procedures to ensure that the results can be compared across the country. This poster will highlight the design of the assessment. I will provide examples of how we communicate our results to policymakers and the public by highlighting NLA findings with respect to broad-scale patterns of and change in biological, chemical, physical, and recreational status of lakes. I will share a list of indicators measured in 2007 and 2012 and discuss the availability of the data. In addition, I look forward to discussing potential interactions between our spatial effort and other, higher-temporal resolution data sets.

62. Terhi Rasilo[1], and Paul A. del Giorgio[1]

Winter methane in boreal lakes

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Lakes are important sources of greenhouse gases (GHG) to the atmosphere, emitting both carbon dioxide (CO_2) and methane (CH_4). However, by not considering the seasonal variation in GHG dynamics, annual estimates of GHG emissions from boreal

lakes will be biased, since gas dynamics vary seasonally, and emissions are inhibited during winter by ice cover. GHG buildup under ice and in hypolimnetic waters can result in rapid, short-term degassing during ice thaw and autumn turnover, respectively, creating intense moments of GHG emissions that are often overlooked. Under-ice CH_4 accumulation occurs in some regions (e.g. subarctic lakes) but not others (e.g. in some boreal lakes). To investigate this inconsistency in more detail, we conducted seasonal measurements of CH_4 and CO_2 concentrations of 13 boreal lakes in Québec. Under ice accumulation of CH_4 was only observed in some of the lakes, while for almost all lakes, CH_4 concentrations and fluxes increased during summer. Our results suggest that especially patterns in annual lake CH_4 dynamics are extremely heterogeneous in the boreal zone. While winter accumulation of CO_2 and subsequent emissions following ice melt represent a major contribution to the annual CO_2 flux, it is not always the case for CH_4, since for some lakes, peak CH_4 fluxes occur in late summer and represent the bulk of annual emissions. Our results collectively suggest that seasonal GHG patterns are inconsistent in boreal lakes, and it is therefore important to account for such seasonal heterogeneity to generate reliable emissions budgets for boreal lakes.

63. Jordan S. Read[1], Luke A. Winslow[2], Gretchen J.A. Hansen[3], Jamon Van Den Hoek[4], Paul C. Hanson[5], Louise C. Bruce[6], Corey D. Markfort[7]

Simulating 2,368 temperate lakes reveals weak coherence in stratification phenology

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Changes in water temperatures resulting from climate warming can alter the structure and function of aquatic ecosystems. Lake-specific physical characteristics may play a role in mediating individual lake responses to climate. Past mechanistic studies of lake-climate interactions have simulated generic lake classes at large spatial scales or performed detailed analyses of small numbers of real lakes. Understanding the diversity of lake responses to climate change across landscapes requires a hybrid approach that couples site-specific lake characteristics with broad-scale environmental drivers. This study provides a substantial advancement in lake ecosystem modeling by combining open-source tools with freely available continental-scale data to mechanistically model daily temperatures for 2,368 Wisconsin lakes over three decades (1979-2011). The model accurately predicted observed surface layer temperatures (RMSE: 1.74°C) and the presence/absence of stratification (81.1% agreement). Among-lake coherence was strong for surface temperatures and weak for the timing of stratification, suggesting individual lake characteristics mediate some –

but not all – ecologically relevant lake responses to climate.

64. D.C. Richardson[1], C.C. Carey[2], D.A. Bruesewitz[3], K.C. Weathers[4]

Intra- and inter-annual variability in metabolism in an oligotrophic lake

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Because of their position in the landscape and hydrological network, lakes can be sentinels of changes in weather and watershed land use. These changes can be quantified through metrics of ecosystem function (e.g., metabolism) that integrate processes across spatial and temporal scales. Recently, high-frequency open water techniques have allowed greater resolution of metabolic estimates to examine metabolism heterogeneity and process drivers, particularly in oligotrophic systems. However, few studies have used high frequency data to examine the reactivity of a lake to change over multi-year temporal scales. Here, we present an analysis of seven years of open-water metabolism estimates in Lake Sunapee, a large, temperate oligotrophic GLEON site in New Hampshire, USA. We examined inter- and intra-annual variability in metabolism, specifically gross primary production (GPP) and respiration (R). We observed increasing annual GPP and R in each successive summer that paralleled increases in littoral, but not pelagic, phosphorus concentrations. Episodic events had short-term effects on metabolism mediated by lake mixing. Daily estimates of GPP and R were positively correlated with stable and warm days and metabolism model fits were best on sunny, warm days indicating the importance of considering lake physics when evaluating daily metabolism data. Using high-frequency data to calculate metabolic parameters, we demonstrate how lakes can act as sentinels for anthropogenically-driven change in both climate and the watershed. Furthermore, our data suggest that ecosystem metrics such as metabolism may be a more sensitive metric for measuring eutrophication than structural metrics such as pelagic nutrient concentrations.

65. James A. RUSAK[1], Dominic Vachon[2], Christopher T. Solomon[3] and Christopher McConnell[1]

Interannual variability in O_2 and CO_2-based metabolism estimates in a north-temperate dimictic lake

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The diel dissolved oxygen (DO) technique for estimating lake metabolism assumes that

changes in oxygen concentration of a body of water reflect the biological balance between photosynthetic production and respiratory consumption as well as the physical exchange of oxygen between air and water. Production of DO via photosynthesis occurs only during daylight whereas consumption of DO occurs throughout the diel period and is the only metabolic process occurring at night. Thus, net ecosystem production (NEP), ecosystem respiration (R), and gross primary production (GPP) can be directly quantified by measuring temporal changes in DO concentration throughout a 24-h period. Although the high-frequency *in-situ* measurement of DO in surface waters needed to estimate lake metabolism is now relatively routine, the *in-situ* measurement of CO_2 is only an emerging technology that is yet to be widely deployed. We compare *in-situ* DO and CO_2 concentrations measured simultaneously in an oligotrophic northern lake in Ontario for similarities and differences and evaluate how patterns of metabolism vary among years.

66. Nihar R. Samal[1], Don C. Pierson[2], Mark S. Zion[2], Klaus D. Joehnk[3], Emmet M. Owens[4], Elliot Schneiderman[2]

Sensitivity analysis on reservoir water temperature under future climate change

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Increasing concentrations of atmospheric CO_2 and other greenhouse gases leads to the possibility of future climatic warming, the extent of which has been projected using General Circulation Models (GCMs). The potential impact of climate change on lakes and reservoirs will be strongly influenced by changes in thermal stratification and mixing. However, systematic investigations of the effects of climate change on reservoir hydrodynamics are not common. Future simulations of reservoir water temperature based on three Global Circulation Models (CGCM3, ECHAM & GISS), and each of three emission scenarios (A1B, A2 and B1) for the 2081-2100 future period are developed using a lumped watershed model (Generalized Watershed Loading Functions-Variable Source Area model or GWLF-VSA) coupled to a one dimensional reservoir hydrothermal model. GCM simulated values of mean daily air temperature, wind speed, and solar radiation were used to produce change factors that were applied to a 39 year record of local meteorological data to produce future climate scenarios. In this study we perform a sensitivity analysis on reservoir water temperature considering the meteorological and watershed effects under present day climate data (baseline conditions) and future scenarios (change factor adjusted baseline conditions). We show that the onset of stratification is most sensitive to future changes in air temperature and the timing of stratification loss is most sensitive to future changes in wind speed. By identifying the dominant physical processes affecting the reservoir water temperature, these results can provide guidance for others simulating the effects of climate change on lake and reservoir hydrodynamics.

67. Arianto B. Santoso[1] and David P. Hamilton[1]

Pulse emission of methane from a small eutrophic lake

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Production of methane (CH_4) in lakes, which is mainly sourced from organic material degradation can either be lost due to oxidation or escaped to the atmosphere as green gashouse gas. However due to variability in production, internal cycle as well as emission pathway leads CH_4 emission estimates from lakes are relatively challenging tasks. We investigated CH_4 dynamics of a relatively small eutrophic lake (Lake Okaro, New Zealand) in order to better understand its source, oxidation and atmospheric release. Monthly observation of dissolved CH_4 over one year period as well as peeper incubation over one month during stratification and mixing period were conducted in this regard. We estimated that CH_4 released from the sediment into water column is as high as 0.4mmolm^{-2}d^{-1} and being accumulated in the hypolimnion in the period of stable stratification. Atmospheric flux is estimated around 0.1 mmol m^{-2} d^{-1}, however as destratification started high pulse (2.5 to 6.0 mmol CH_4 m^{-2} d^{-1}) emission to the atmosphere occurs. Based on mass balance estimation about 2.3 x 10^{4}mol of CH_4 is accumulated in the hypolimnion from the start of stratification until autumn overturn. Of the total hypolimnetic CH_4 storage, only 11% of that can escape to the atmosphere during the overturn. This indicates that CH_4 oxidation in water column has an important role in regulating CH_4 flux from the lake. However, massive release of CH_4 can still be occurring in this lake via ebullition as also being noted in this study.

68. Facundo Scordo [1,2], María C. Piccolo [1,2], Gerardo M.E. Perillo [1,3]

Evolution of Muster and Colhué Huapí lakes (1998-2013).*

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Climate data and satellite information are important tools to understand the dynamics of water bodies. The evolution of Muster and Colhué Huapí lakes in the period 1998-2013 was studied. The former is a deep oligotrophic lake and the latter is a large shallow lake, both are interconnected by the Senguer river. The aim of this study was to compare the changes occurred in the area of those lakes based on satellite images information (LANDSAT 5,7 and 8) and correlate them with results from climate data analysis (rainfall and temperature) records provided by the Subsecretaría de Recursos Hídricos de la Nación (SSRH). Within the period 1998-2013, dry, wet and normal years were identified. Also, the occurrence of extreme events was studied by Palmer Index analysis. The results showed that in the study period, lakes changed from dry to wet condition every 8 years. In 2000 Coluhé Huapí lake area was 283 km^2 and increased until 2008, when it reached its largest extension (761 km^2) to decrease to 337 km^2 in 2013. Local climate data and Palmer Index results did not show an acceptable

correlation with lakes area variations. This could be explained as lakes are watershed base level so the basin processes could have more influence over the lakes area than local climate conditions. Also anthropic activities in the area are significant and they will be considered in following studies.

69. Carina Seitz[1, 2], Alejandro J. Vitale[1, 2], Gerardo M.E. Perillo[1, 2], M. Cintia Piccolo[1, 2]

Geomorphologic study of La Salada Lake (Argentina) Employing Unmanned Autonomous Vehicles[a, b]

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[b]Project SAFER funded by IAI and NSF

Shallow lakes may have large areal extensions but for most of the water body depths are too low for employing standard echosounders and boats. Furthermore, their borders tend to be diffuse both because of the presence of macrophytes and the wetlands that surround them. The Argentina Pampas is covered by large number of shallow lakes, which are understudied from the geomorphologic point of view. Therefore, the aim of this article is to present new methodology for their geomorphologic analysis as it is a basic element to further limnological studies. Tests of the methodology are carried out at La Salada shallow lake (Buenos Aires, Argentina), a site that belongs both to the *Pampa[2]* and *SAFER* networks. The methodology developed combines the use an open source acoustic profiler mounted over an autonomous small boat plus aerial high-resolution photography employing an unmanned hexacopter. The former allows to obtain: i) an acoustic profile of lake bottom sediment and ii) georeferenced bathymetry in real-time. The fully autonomous hexacopter can map the coast and the wetlands. Resulting 3D maps can be further integrated with sedimentologic data take with grab samples (for bottom sediments) and a modified Phleger corer for subsurface sedimentary facies. The developed equipment has demonstrated advantages over traditional bathymetric methods both operating costs such as integrating the physical data with the geoposition data.

70. Craig Snortheim[1], Paul C. Hanson[2], Trina McMahon[1], Jordan S. Read[3], Luke Winslow[2], Cayelan C. Carey[4], Renato Figueiredo[5], Louise C. Bruce[6]

Response of anoxia and phytoplankton in Lake Mendota to seasonally and diurnally asymmetric changes in climate drivers

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Changing climate poses substantial threats to lake ecosystems globally. Changes in climate have already altered physical, chemical and biological processes in lakes, including many ecologically significant processes, such as hypolimnetic anoxia and phytoplankton blooms. To make predictions of future changes in lakes, numerical models have been used to simulate scenarios of changing climate, often using monthly mean change factors for meteorological drivers. While this approach inherently captures asymmetric changes across seasons, it does not capture day-night asymmetry in climate drivers. Because certain physical and biogeochemical processes occur at different times of day, day-night asymmetry of changing climate drivers can lead to non-linear responses in these processes. How do ecologically significant lake processes respond to climate drivers changed at different times of day, and through different seasons of the year? In this project, we investigated the response of anoxia and phytoplankton blooms in Lake Mendota, WI to manipulated meteorological drivers at different times of day, through different seasons, using the 1-dimensional coupled hydrodynamic and biogeochemical model GLM-FABM-AED. Driver shifts were applied as an additive increase from an observed baseline year, with seasons defined by months (e.g. spring is Mar, Apr & May) and day/night defined by a threshold of shortwave radiation. We found that increases in air temperature (AT) tended to increase the duration of anoxia regardless of the timing of driver changes, but all-day changes during spring had the greatest positive effect on the anoxia duration. Nighttime changes in AT during autumn had a disproportionately high positive effect, which was not statistically different from autumn all-day changes. Anoxic factor was increased in all cases by elevated AT, with the greatest positive effect seen during the summer. Responses of phytoplankton peak concentration and timing varied by functional group, but summer and daytime changes had the greatest effect.

71. Peter A. Staehr[1], Ismael A. Kimirei[2] Catherine M. O'Reilly[3]

Projections of climate change effects on Lake Tanganyika

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Climate change will disproportionately affect developing countries. Our project will provide fundamental information regarding the extent to which climate-driven changes are influencing the dwindling pelagic fish catches in Lake Tanganyika, Tanzania. While some studies have indicated a strong interaction between climate and fish yields, others have disputed this relationship. However, systematic collection of data on lake physics, primary production and fisheries and application of novel lake models that account for interactions between climate and fish yields will provide a powerful way to obtain valuable new insight that may resolve the current dispute. Our study incorporates all possible drivers of both ecosystem change and fisheries

variability and is therefore of high relevance for Tanzania as well as the other riparian countries in the Lake Tanganyika basin. This is particularly important as informed, proper and sound management of the fishery resources in the lake hinges on a solid data foundation. In this poster we present a new 5 year project which will train Tanzanian scientists and students in sampling, analysing and interpreting data on lake physical, chemical and biological conditions. These data will be incorporated into models that describe lake–climate interactions and evaluate impacts on primary production and fish productivity. Information on lake functioning and responses to pressures will be disseminated to local stakeholders (small and larger scale fishermen, lake managers and civil society) through collaboration with beach management units using a diverse means of communication (websites, policy briefs, pamphlets, posters, annual reports etc.) and a series of workshops and outreach with local schools. By combining novel research and capacity building of regional researchers, lake managers and key stakeholders of the lake, we aim to set the grounds for an improved and informed long-term sustainable environmental management of natural resources in Lake Tanganyika in an era of climate change and rapid human population growth.

72. Marju Tamm[1], Rene Freiberg[1], Ilmar Tonno[1], Peeter Noges[1] and Tiina Noges[1]

Pigment-based chemotaxonomy - a quick alternative to determine algal assemblages in large shallow eutrophic lake?

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Pigment-based chemotaxonomy and CHEMTAX software has proven to be valuable phytoplankton monitoring tool in marine environments, but is yet underdeveloped to determine algal assemblages in freshwater ecosystems. The main objectives of this study were (1) to compare the results of direct microscopy and CHEMTAX in describing phytoplankton community composition dynamics in a large, shallow and eutrophic lake; (2) to analyze the effectiveness of pigment-based method to detect changes in phytoplankton seasonal dynamics and during rapid bloom periods; (3) to assess the suitability of specific marker pigments and available marker pigment:chlorophyll *a* ratios to follow seasonal changes in an eutrophic freshwater environment. 5-year (2009-2013) parallel phytoplankton assessment by direct microscopy and by CHEMTAX was conducted using published marker pigment:chlorophyll a ratios. Despite displaying some differences from microscopy, pigment-based method successfully described the overall pattern of phytoplankton community dynamics during seasonal cycle in eutrophic lake. Good agreement between these two methods was achieved for most of the major phytoplankton groups – cyanobacteria, chlorophytes, diatoms and cryptophytes. Agreement was poor in case of chrysophytes and dinoflagellates. Our study shows clearly that published marker pigment:chlorophyll a ratios can be used to describe algal class abundances, but they need to be tested in specific freshwater environment. Broader use of this method would enable to expand monitoring networks and increase measurement frequencies of freshwater ecosystems to meet the goals of Water Framework Directive.

73. Tara N. Tapics[1], Maxime Fredette[1], Yannick Huot[1]

High frequency and high spatial resolution planktonic community studies using an automated profiling platform: 2. Phytoplankton succession

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Phytoplankton community structure is ecologically significant, but the difficulty of obtaining high temporal- and spatial-resolution datasets has until recently limited studies of its evolution through time ('phytoplankton succession'). Many changes in community structure through time are natural, albeit poorly understood, and influenced by factors including weather events and changes in season. However, others, like the transition from eukaryote- to prokaryote-dominated systems, are often the result of anthropogenic pressures, and are associated with undesirable outcomes such as the alteration of food webs and the adulteration of water resources. Using data from the imaging flow cytometer, we aim to discover factors influencing community shifts and develop capacity to predict these shifts. We will present a time series of data collected in lake Montjoie (Québec, Canada) spanning two summers from such an instrument deployed on an autonomous platform.

74. *Terry, J. A.[1], Baulch, H. M.[1], Bauer, J.[1], Sagin, J.[1], and Lindenschmidt, K.-E[1].*

Whole lake modeling to understand complex processes

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On the Canadian Prairies, source waters exist within a landscape of intensive agricultural and ever-increasing municipal development and industrial activities. Widespread problems associated with eutrophication are creating major challenges for the provision of safe drinking water. The development of models and monitoring tools to provide early warning of conditions likely to lead to harmful algal blooms will help understand and manage the challenges municipalities face providing high quality water to their citizens. Buffalo Pound Lake is a eutrophic reservoir in rural Saskatchewan. Real-time monitoring using sensor-based technology on a recently launched lake observatory buoy, together with long-term datasets spanning 10-30 years, and with physical sampling, provide multiple opportunities to assess the antecedent conditions associated with harmful algal blooms of varying attributes. The project is the first application of a two-dimensional coupled hydrodynamic-ecological model to the lake system driven by the real-time data collected from the buoy. The lake is the first monitoring site of the Global Lake Ecological Observatory Network (GLEON) in Western Canada, and creates some unique modeling challenges including landscape, morphology and climatic environment. The work will focus on adaptive parameter setting and sensitivity analysis for advanced simulation of whole lake processes to develop predictive tools for short-term forecasting of bloom development. As such, the outcomes of the project will help strengthen the existing knowledge base of GLEON as well as providing new insights on global and regional lake variability.

75. Mridul K. Thomas[1] and Francesco Pomati[1]

Uncovering the drivers of single-cell phytoplankton trait gradients: selection, plasticity or both?

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Phytoplankton populations are subject to selection pressures that vary across space and time. Understanding the ecological consequences of these pressures on phytoplankton communities will help us understand the importance of different drivers on community assembly. Previously, this has been a challenge due to the difficulties in measuring traits under selection in natural communities, but this has changed with the advancement of scanning flow-cytometry technology. We use high-frequency flow cytometry data from a eutrophic lake to show that important phytoplankton traits (cell size and fluorescence, a proxy for pigmentation type) display strong patterns with depth. These trait gradients are consistent with predictions based on selection: 1) larger cells are more prevalent in deeper waters, as expected based on differential sinking rates, and 2) changes in fluorescence with depth, as expected based on the differential loss of light spectrum due to absorption and scattering. However, physiological plasticity may also play an important role, with cells regulating pigment composition based on the light spectrum available. We investigate the time-scale of trait changes to attempt to distinguish between these explanations, but further experiments will be needed to conclusively disentangle ecological and physiological responses.

76. Denise Tonetta[1], Mauricio M. Petrucio[1], and Peter A. Staehr[2]

Do pelagic and littoral sites show the same dissolved oxygen variation pattern?

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Dissolved oxygen is one of the most important variables for aquatic environments and is used to determine metabolic rates. Many variables can influence metabolic processes, and consequently lakes may exhibit spatial variation. The aim of this study was to evaluate the dissolved oxygen and water temperature variation pattern, and to verify if littoral and pelagic sites show the same values and variation pattern. This study was conducted in Peri Lake, a subtropical coastal lake in Southern Brazil. Dissolved oxygen and water temperature sensors were deployed at the subsurface from the littoral site (~ 1 meter depth) and pelagic site (~ 4 meter depth), and variables were sampled at 15-minute intervals over 48 hours. Additionally, water temperature sensors showed both sites were full mixing. The littoral site showed on average lower dissolved oxygen and water temperature (7.65 mg/L; 27.24 °C, respectively) than the pelagic site (7.94 mg/L and 27.48 °C, respectively). At both sites temperature and oxygen increased during the day and decreased during the night. The coefficient of variation was larger at the littoral site than the pelagic site, and can be related to more variable inputs of low oxygen water from upwelling deeper waters, and the more

turbid waters. At the littoral site oxygen decreased faster during the night, suggesting high oxygen consumption rates from sediments. In conclusion, the higher variability in oxygen at the littoral site is related to low local depth and direct influence from the terrestrial environment.

77. *Jeng-Wei Tsai*[1]

Trend of Metal Biomagnification and Toxicity: the role of lake metabolism plays across the global

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Metal (e.g. mercury, arsenic and cadmium) pollutions in aquatic ecosystems remain a global concern and are of interest to aquatic ecotoxicologist, because metals can biomagnify along the food chain to harmful levels in fish, their predators or consumers. Understanding whole ecosystem metabolism (EM) in the natural environment is critical for management, because gross primary production (GPP) and ecosystem respiration (R) are the major metabolic pathways of carbon and provide a measure of the overall biological activity of an ecosystem. Scientists recently suggest that the EM could serve as a sentinel to monitor the effects of environmental change on regional aquatic ecosystem function and structure. Because EM of freshwater provides a fundamental index of cross-ecosystem connectivity that responds to natural and human disturbances (e.g., deforestation and chemical disposition), we hypothesize that the addition of easily degradable organic materials during the periods of higher GPP might consequently facilitate microbial activity, maximize the mineralization of recalcitrant organic matters (i.e., priming effect) and thus stimulate the metal biomagnification. Therefore, the euntrophication resulted from climate change or land cover changes might enhance the metal biomagnifications in lakes located in high latitude area, surrounded by natural forests, characterized by high allochthony/water color or in seasons with low productivity. Samplings and investigations will be conducted by comparing the factors or process that control metal biomagnifications across lakes at local, regional and global scale. Long-term periodically observations of lake metabolism, metal biomagnifiation will be regularly monitored in fish, zooplankton, algae and other aquatic species in lakes or ponds with contrasting trophic status and watershed coverage across the globe. Field transplantation experiments will be conducted to quantify the metal trophic transfer between two trophic levels and to investigate the change in their susceptibility to metal stress. In addition to the scientific findings, results are also expected to contribute to the knowledge of ecosystem conservation, management, remediation, environmental legislations and aquacultural practices.

78. Jeng-Wei Tsai[1]*, and Chih-Yu Chiu*[2]

Episodic lack of winter and spring monsoons induced metabolic shifts in a subtropical shallow lake in Taiwan

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We investigated how an episodic lack of winter and spring monsoons, as an extreme weather event, would affect the dynamics of ecosystem metabolism in a mesotrophic, seepage shallow lake in northeastern Taiwan. A permanent wireless sensor network provided high-frequency free-water dissolved oxygen, water temperature profiles and meteorological data, which we used to estimate daily values of gross primary production (GPP), ecosystem respiration (R), and net ecosystem production (NEP).
Results revealed that the disappearance of monsoons decreased lake volume, condensed waterborne nutrients, stimulated the development of algal biomass, promoted stratification, and resulted in the regime shift in lake metabolism. Pelagic GPP and R both initially stimulated, followed by abrupt collapses due to the stronger stratification of water column. The lake was characterized by a rapid metabolic shift from heterotrophy to a highly autotrophic status when the water level ebbing to the lowest level. Autotrophy of the lake profited from a greater decline in R instead of stimulating the GPP. The lost of priming effects in heterotrophic process by benthic photosynthetically produced DOC might describe stronger R declines of the lake in droughts. This study implicated that controlling waterborne nutrients could be important to make the lake ecosystems less susceptible to a predicted dryer and warmer climate or anthropogenic water withdraw in subtropical areas.

79. Jeng-Wei Tsai[1], Huilin Zhuang[1] and Keli Lu[1]

Research of ecosystem metabolism and metal biomagnification

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It is a globe issue that the aquatic ecosystems polluted metals and metals can biomagnify along the food chain to harmful levels in fish. An aquatic ecosystems metabolism can reflect the variation around the space, and we can project the coming year. Aim of this study seeks to understand how the ecosystems metabolism affects the trophic transfer of metals through the food chain. It will keep track of the daily condition and quantifications the data by using water quality multiprobe in the south of Taiwan. Besides, we will collect the data from ecosystems metabolism and water chemistry analysis. Next, we are going to carry out to test the concentration of metals from the fish. Eventually, we will get the much more data from the space, and know the condition from now to future. The result can be the referral to restore the destroyed aquatic ecosystems.

80. Theresa M. Warner[1], Rachel M. Pilla[1], Lesley B. Knoll[2], Jennifer A. Bentrup[1], Taylor H. Leach[1], and Craig E. Williamson[1]

Changes in dissolved oxygen over time: does response depend on lake transparency?

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The thermal profiles of clear lakes have been shown to respond to climate warming more strongly than those in more colored lakes with higher levels of dissolved organic carbon. Similarly, dissolved oxygen (DO) has been shown to respond more strongly to climate warming in clear versus colored lakes. Here we examined a variety of different metrics related to changes in DO with depth in a clear and a colored lake over a 26-year period. Oligotrophic Lake Giles and dystrophic Lake Lacawac are located in Pennsylvania and the data included two distinct time periods: 1988 to 1996 and 2007 to 2013. A wide variety of DO-related metrics derived from DO concentration as well as DO percent saturation were tested and analyzed for changes over time. The DO metrics that responded most strongly were (1) the difference between the maximum and minimum percent saturation, (2) the slope between this maximum and minimum percent saturation, (3) the average DO (percent saturation or concentration) over the bottom three meters, and (4) the depth of the maximum DO concentration. Regression analysis of these metrics over time showed R^2 values up to 0.72 for clear Lake Giles. The maximum R^2 for colored Lake Lacawac in contrast was only 0.25. The DO changes in Lake Giles appear to be related to increases in dissolved organic carbon and increased precipitation in more recent years. These findings support previous evidence that clear lakes are more effective sentinels of climate change than are colored lakes.

81. Chelsea A. Weirich[1], Sarah L. Bartlett[2], Jennifer Klug[3], Todd R. Miller[1].

Challenging the Chlorophyll Management Practice: A Call for Different Water Quality Monitoring Strategies for Blue-Green Algae

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Blue-green algal monitoring in eutrophic waters protects ecosystem and public health. These photosynthetic bacteria accumulate to extreme levels in key water bodies decreasing water clarity, dissolved oxygen, and produce secondary metabolites toxic to animals and humans. The WHO and local health departments use chlorophyll and cell density as probable indicators of toxin production; however, studies show cell density and chlorophyll concentrations are poor correlates of microcystin levels. Additionally, other cyanotoxins, such as neurotoxins and other non-ribosomally synthesized peptides produced by cyanobacteria, may be present and unaccounted for when estimating health risk by these standards. We asked whether traditional water quality parameters correlate with toxin concentrations in freshwater lakes. Water samples were collected from six sites on Lake Winnebago, WI and from four sites on Lake Lillinonah, CT, as part of the Lake Lillinonah Volunteer Water Quality Monitoring program (2008-2012). Chlorophyll-a and total microcystins from Winnebago were significantly correlated at only three of six sites during the summer of 2013; one of these three sites was sampled only half as frequently as the others, and at the other two sites, these variables were weakly correlated (R=0.52,0.44; p=0.01,0.04). Additionally, cyanotoxin analyses show that poor water quality standards (i.e. low visibility in the water column, blue-green algae scums, low recreational potential) need

not be present for high cyanotoxin concentrations (ranging from >2µg/l to 974 µg/l) and cyanotoxin variability in Lake Lillinonah. These results suggest that practices other than weekly sampling for traditional water quality variables should be considered for monitoring of persistent cyanobacterial harmful algal blooms in lakes.

82. William. E. West[1], Kevin. P. Creamer[1], James. J. Coloso[1], Stuart. E. Jones[1]

Landscape-informed strategies for estimating contributions to the global methane cycle

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Freshwater inland lakes are a significant source of methane (CH_4) to the atmosphere. However, current global estimates of lake contributions to atmospheric CH_4 are static in nature. More specifically, current global estimates are based on the product of average empirical rates and global lake surface area. To begin to address this issue, we conducted a survey of methane production, oxidation, and emission rates for thirty-five lakes in near pristine and agriculturally-dominated watersheds across the upper Midwest USA. Our survey revealed contrasts between CH_4 production, consumption, and emission rates from lakes in forested versus heavily agricultural watersheds. We also used our survey results to generate models of CH_4 production and emissions. Our models use lake and landscape predictors in order to facilitate the extrapolation of rates to broader spatial scales. We believe the combination of broad spatial surveys and landscape-informed modeling will be important for the prediction of lake CH_4 emissions at regional to global scales under future climate and land use scenarios.

83. Amanda K. WINEGARDNER[1], Beatrix E. BEISNER[2], and Irene GREGORY-EAVES[2]

Diatom diversity patterns over the past ~ 150 years across the continental United States: identifying regional hotspots of biodiversity change using paleolimnology and long-term monitoring approaches

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The detection of changes or trends in lake data are among the most important goals of long-term monitoring programs. The National Lake Assessment (NLA) program administered by the US Environmental Protection Agency samples approximately 1000 lakes every five years, providing open-access data on biodiversity, lake water chemistry, basin, and catchment characteristics. The companion paleolimnological (lake sediment) part of this database can offer unique insights into how aquatic diversity has changed through time and can be more immediately used to test questions arising from the analysis of water column data collected across NLA lakes. The focus of this project therefore, is to compare diatom assemblages from pre-industrial (where possible) or baseline sediments, to those found in modern (2007) sediments, generating estimates of beta-diversity. My specific objectives are to: (1)

Quantify patterns in latitudinal richness across lakes and regions with different disturbance histories, (2) Map diatom beta-diversity through both time (bottom and surface sediment core samples) and space (between lakes), creating a visual depiction of beta-diversity hot spots across the US, and (3) Relate landscape-level anthropogenic changes/trends to diatom diversity and beta-diversity, with a particular focus on alterations that influence lakeshore condition. This work will contribute to an understanding of how anthropogenic, landscape-scale changes affect diatom (plankton) alpha and beta diversity across the US, through the combination of both long-term monitoring and paleolimnogical data.

84. Hiroshi Yajima[1]

Effects of the construction of an artificial shallow area in Lake Shinji on waves and turbidity

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Lake Shinji is a brackish shallow lake. Its surface area is 86.8 km2 and the average water depth is 4.5 m. In 2001 the Japanese government (MLIT) started a project to construct an artificial shallow area around the shoreline where concrete embankments had been constructed and the water depth became deeper. One of the main objects of the project is to reduce wave energy and inhibit the re-suspension of bottom sediments, which is expected to decrease turbidity in the lake. In order to reveal the effect of constructing an artificial shallow area on waves and turbidity, I performed field surveys of measuring waves, currents and turbidities at an artificial shallow area as well as an adjacent deeper area in the lake. Moreover wave analysis using SWAN model and turbidity analysis using ELCOM model were performed to evaluate the change of wave characteristics, bottom share stresses and turbidity due to the water depth change. The field survey showed that wave heights in the artificial shallow area became smaller than the deeper area. But there were no significant turbidity differences between two areas. From numerical analysis, it was cleared that the bottom shear stress became larger in a shallow area than a deeper area even though wave heights became smaller and turbidity was slightly promoted in a shallower area, which supports the findings of field results.

85. Yang Yang[1], William Colom[1], Don Pierson[1], Kurt Pettersson[1]

Phytoplankton dynamics and water column stability in summer period

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Physical forces, particularly the climate-induced thermal stratification has been proposed to be the steering one to shape the community. A regular temperate lake gets stratified during summer time when the temperature increases and causes density differences between upper and bottom layer. This study first exhibited the temporal pattern of total biomass of phytoplankton at Lake Erken based on 19 years data spanning the past 21 years, then combining with long-term high frequent monitoring data during summer period, we calculated stability indices - Schmidt

stability and Wedderburn number in order to investigate the relationship between water stability and phytoplankton dynamics. Temporal variations of community composition suggested that thermal stratification not only influence the total biomass, but also the species composition. Ordinations exhibited that, at Lake Erken, Schmidt stability and nutrient concentration, especially nitrate and silicate in epilimnion are the significant factors for phytoplankton development. Water column stability is suggested to be the primary selection force for the composition of phytoplankton via 1) deciding the time length that phytoplankton could spend in light-sufficient region; and 2) influencing the nutrient availability in the epilimnion; 3) slowing down the sediment loss rate and transporting some species up again in the upper part; stratification favors the small-sized species and species with the ability to migrate vertically or regulate buoyancy, in addition, during stratification period, species diversity is negatively correlated with water stability, which is in line with the hypothesis that low diversity in summer is mainly due to the stratification.

86. Huaxia Yao[1]

Predicting calcium dynamics in a Canadian-Shield lake under future climate and deposition scenarios

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Calcium (Ca) decline in headwater lakes of the Canadian Shield is becoming a potential threat to the biota of aquatic ecosystems. When Ca concentrations reach a threshold 1.5 mg/L, the abundance of certain zooplankton, and potentially other invertebrates, will decrease in lakes. For example, the Ca level of Harp Lake (south-central Ontario) has declined from 3.3 mg/L in 1978 to 2.3 mg/L in 2012, roughly decreasing by 30% over 35 years and being relatively non-sensitive to acid rains. How will the Ca level change in future and when will it drop down to this critical threshold? We used a mass balance model for this lake to analyze and predict possible Ca changes under various climate and atmospheric deposition scenarios. The model generated acceptable fits when validated using historical inflow/outflow, chemistry and precipitation data from 1978-2012. Future climatic time series for 2013-2100 were obtained from the Canadian Regional Climate Model and future daily runoff in the catchment was generated using Brook90 hydrology model. Nine possible scenarios with variable runoff and stream Ca concentrations were used to predict lake Ca concentrations in Harp Lake. In the worst case of climatic and depositional scenario, Ca in Harp could drop to 1.6 mg/L in 2100 from 2.3 mg/L at present, and in the best case it may rise to 2.7 mg/L. Although Harp Lake is not immediately at risk, there are many others lakes whose current Ca levels are lower and this method can help inform when policy intervention may be desirable.

87. Jacob P. Ziegler[1], Dylan J. Fraser[2], and Chris T. Solomon[1]

Evolutionary and plastic responses of bluegill (*Lepomismacrochirus*) to increasein dissolved organic carbon in lakes.

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Browning of inland waters through allochthonous inputs of dissolved organic carbon (DOC) negatively impacts fish production and growth rates. One explanation for decreased growth rates in high DOC lakes is that productive space for both zooplankton and zoobenthos is decreased due to light limitation. As a result, fish are likely food limited within these systems. However, an evolutionary component could be at play as well, whereby, selection of slow growing late maturing individuals occurs in high DOC lakes as fish invest more energy in foraging and less in growth and reproduction. To test this hypothesis we collected bluegill from 10 lakes that ranged in DOC and were close in proximity to each other but well isolated from fish movement. We sampled bluegill for micro satellite analysis, morphology, gonad mass, age at maturity, and growth rates. Preliminary results suggest that bluegill in darker lakes were slower growing and matured later. In addition to completing our DNA analysis, we would like to use high frequency sensor data to try and link environmental factors like production to both plastic responses of fish and evolutionary changes within these communities.

88. Jake A. Zwart[1], Christopher T. Solomon[2], Brian C. Weidel[3], and Stuart E. Jones[1]

Spatiotemporal controls of lake heterotrophy: insights from coupling high frequency carbon loads and lake metabolism estimates

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High-frequency data are increasingly used in aquatic systems to infer important ecosystem processes, such as daily estimates of lake metabolism using diel oxygen cycles. Previous work has sought to interpret spatiotemporal dynamics in lake metabolism parameters using in-lake predictors, such as nutrient concentrations and lake hydrodynamics. In contrast, watershed drivers are rarely considered. In this study, we couple high-frequency estimates of terrestrial carbon loads with lake metabolism estimates to examine watershed drivers of lake heterotrophy. We use 3 lakes varying in hydrology from seepage to drainage lakes and terrestrial carbon load. All lakes increased in heterotrophy shortly after storm events, displaying synchronous response to regional weather patterns. The magnitude and duration of increased heterotrophy depended on the magnitude of carbon influx. The results from coupling high frequency estimates of lake metabolism and terrestrial carbon loads suggest a relatively labile terrestrial carbon pool that is respired once transported to the lake. Frequency of increased heterotrophy is regulated by regional weather patterns while the magnitude of this increase is governed by lake hydrologic characteristics.

88. *Orlane Anneville[1], Gaël Dur[1], Emily Nodine[2], Jason D. Stockwell[2], Bastiaan Ibelings[3], and Sami Souissi[4]*

Storm-Blitz: Tracking storm effects on the phytoplankton community using hierarchical clustering and Bayesian probabilities, example from Lake Geneva

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Physical and chemical properties of the pelagic habitat set the requirements of organisms to be able to live or fail. At the scale of the year, temporal changes in these properties induce a change in the pool of species better adapted and likely to outcompete. Consequently, phytoplankton composition evolves according to a pattern that repeats annually. However, this pattern of succession can be disrupted by environmental disturbances associated with changes in meteorological conditions. The present study focus on one of the time series gathered in the framework of the Storm-Blitz project that aims at investigating the impact of storms on phytoplankton communities. We used a method based on hierarchical clustering and Bayesian probabilities to examine long-term (37 years) variability in the seasonal pattern of phytoplankton succession in Lake Geneva. We identified phytoplankton assemblages and analyzed their probability of occurrence to evaluate their temporal dynamic and sensitivity to changes in environmental conditions. We showed that 1) the seasonal patterns of assemblage succession presented important changes over the years in response to both human activity and regional climatic changes, 2) this analytic method underlined mid-term variability in the dynamic of occurrence of phytoplankton assemblages, 3) this mid-term variability reflected the vulnerability of a system where advantages among different species switch continually in responses to changes in habitat opportunities, and finally 4) specific analysis of mid-term variability may help to evaluate the impact of storms on phytoplankton community.

89. *Lisette N. de Senerpont Domis [1], Orlane Anneville[2], Stefan Bertilsson[3], Jennifer Brentrup[4], Justin Brookes[5], Louise Bruce[6], Cayelan Carey[7], Ken Chiu[8], Jesper Christensen[9], David de Motta Marques[10], Elvira de Eyto[11] Evelyn Gaiser[12], Nicole Gallina[13], Sam Fey[14], Paul Hanson[15], Nicole Hayes[4], Amy Hetherington[16], Lindsay Hislop[17], Bas Ibelings[18], Kersti Kangro[19], Lesley Knoll[20], Alo Laas[19], Valerie McCarthy[21], Beth Mette[4], Adam Mulvhill[11] , Kohji Muraoka[22], Emily Nodine[23], Marie Perga[2], Anna Rigosi[5], Jim Rusak[24], Elizabeth Ryder[21] Arianto Santoso[22], Giulia Valerio[25], Chaturangi Wickramaratne[5], Yang Yang[26], and Vicky Veerkamp[21]*

Spring Blitz: Linking changes in water stability to plankton diversity

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The Spring Blitz is a coordinated effort from researchers around the world to link changes in water stability during the onset of stratification to plankton stability. This project makes use of the GLEON network of lake sensors in lakes differing in stratification regime, testing whether lakes with strong stratification in spring develop higher plankton diversity, due to an enhanced spatial heterogeneity favouring the growth of various species and limiting exclusive competitions. The main aim of this project is to study the role water column stability plays in determining plankton diversity in lakes.

An intensive sampling campaign was undertaken by GLEONites in the northern hemisphere during March – June (2013) and in the southern hemisphere spring blitz from September –November 2013. All total of ten lakes have been sampled just before and after the onset of a stable thermocline, although some European and Canadian sites experienced an unusual prolonged winter. Sampling occurred twice a week, using a standard operational procedure we developed to address the specific questions asked in this study. We will present preliminary data on this huge sampling campaign, covering phytoplankton, zooplankton, microbial plankton and abiotic parameters.

90. Eric O. JOHNSON[1]

How to Form a Form – the Art of Data Collection

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Data collection is an important part of our research. Often performed by volunteers, the tools utilized need to be simple and easy to use while at the same time fostering accurate and complete recording.

Focusing on techniques others can use to create or improve data collection forms, this talk will describe principles of design that helped improve the accuracy of both paper and electronic data collection forms used by Craig Williamson's team.

We will then showcase our current data collection software, highlighting specific features that improve collecting accuracy. This software goes beyond typical collection methods, providing color coded interactive, localized guidance and error correction to the data collector. Data collection is also integrated into the research workflow, automatically being validated and uploaded into a central database with metadata, ready for the researchers to analyze.

Students who have been collecting data will share their experiences using the software, suggestions for improvements and be available for questions.

91. Carolyn Maxwell[1], Leon Barmuta[2], Matthew HIPSEY [3]

Monitoring the resilience of the great lakes of Tasmania

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A considerable number of natural and altered lakes exist in the upland region of Tasmania, Australia, and many are connected for the purpose of supporting a substantial hydropower generation scheme. They support a rich biota, but are subject to extensive water level manipulation. Which lakes recover from fluctuations in water level and which do not? Manipulations of water levels in lakes can induce changes in trophic structure and water quality and we will develop robust ways of forecasting how lakes will respond to changes in manipulations of water levels, to minimise extinctions and maintain aesthetics and water quality. This is done through integration of sensor data and models, exemplified for Great Lake and Woods Lake.

92. Zofia E. TARANU[1], Pierre LEGENDRE[1], Irene GREGORY-EAVES[2], and Marieke BEAULIEU[3]

Modeling algal toxin concentrations in a changing world: the importance of cross-scale interactions

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Several factors are believed to determine the concentration of cyanobacteria in lakes. In particular, eutrophication and climate warming are suggested to be driving a global expansion of cyanobacteria in freshwater ecosystems. This is cause for concern not only because of the substantial economic loss it entails, but also because cyanobacteria are known to produce harmful neuro- and hepatotoxins. Importantly, although strong local-scale cyanotoxin models have been described, modeling the abundance of microcystin (a group of cyanotoxins), across broader spatial scales has been difficult and production remains highly dynamic through space and time. For instance, at the local scale (southern Québec lakes), 46% of the microcystin variance was explained by explanatory variables, whereas a meta-analysis developed across Canadian lakes explained far less variance (10% explained). Such scale dependencies may be due, in part, to interactions between processes across different spatial scales (defined as cross-scale interactions), where overarching regional drivers cause local-scale relationships to differ. The goal of this project was thus to develop robust microcystin response models that account for these cross-scale interactions. To address this objective, we analyzed a dataset of >1000 randomly selected lakes, ponds, and reservoirs sampled by the U.S. Environmental Protection Agency (USEPA) and applied generalized zero-inflated mixed-effect models, which effectively modeled the large number of sites with microcystin concentrations below the detection limit, allowed for local relationships to vary by region, and tested the cross-scale interactions among environmental drivers.