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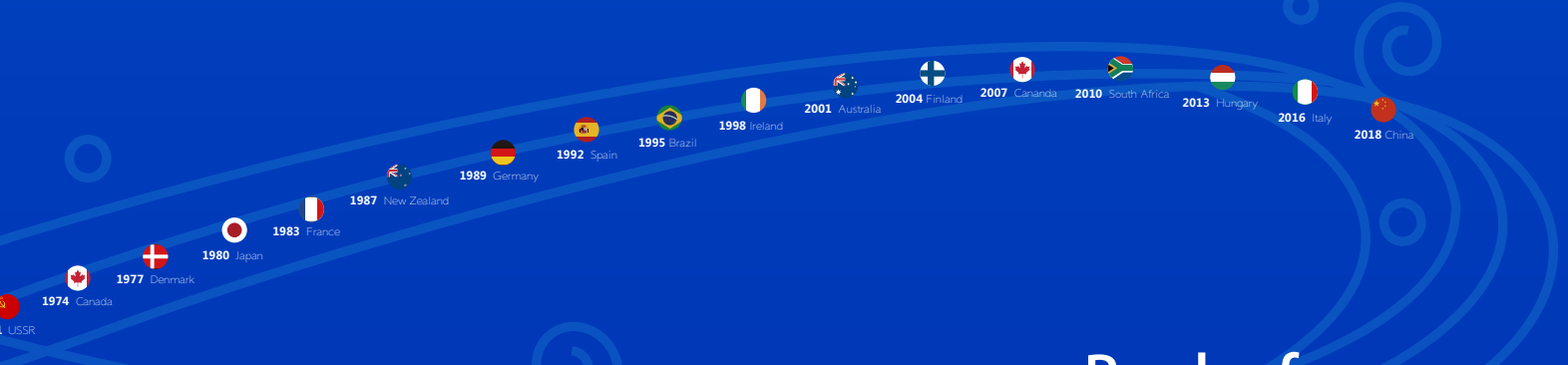
湖沼学—支撑水生态系统保护与修复的科学



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Book of Abstracts

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BOOK OF ANSTRACTS

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Baldi Memorial Lecture: Mixing Dynamics: From Hutchinson to the 21st Century. *Sally MacIntyre*

UCSB, United States

The advent of high resolution instrumentation combined with theory, experimentation, and modeling allows us to extend former classifications and understanding of mixing dynamics of lakes. These new approaches remain underutilized but inclusion will enable predictions of mixing and consequences for the fluxes of nutrients, dissolved gases, and plankton. Hutchinson's lake classification schemes considered the duration and timing of events that create or erode stratification. Internal waves occur with stratification. New classification schemes for internal waves predict whether they are seiches or non-linear, and break near-shore or mid-lake. By classifying lakes with these schemes, we will develop improved understanding of the dynamics of dimictic, polymictic and monomictic lakes, whether communities of organisms are layered or dispersed, and whether nutrient supply to the euphotic zone is due to recycling within it or to abiotic processes inducing fluxes from deeper depths. The mixing of incoming plumes of stormwater with their load of nutrients or pollutants depends on the extent of stratification and resultant internal wave dynamics. Convection, that is circulation driven by cooling at the air-water interface, sediments heating overlying water, or horizontal variability in rates of heating or cooling, is now known to be a critical driver of circulation in lakes at all latitudes. Inclusion of these processes enable prediction of whether flows from inshore are concentrated or diluted. Using schemes that contrast time scales of mixing and of advection with time scales of reaction rates will allow us to predict the impacts of changes in land use and climate on species composition, ecosystem productivity, greenhouse gas formation and evasion, and the overall quality of our inland waters.

Protecting and restoring rivers in the UN 'Water Action Decade'

Stuart Bunn

Australian Rivers Institute Griffith University, Australia

Eco-evolutionary dynamics and the response of aquatic biota and ecosystems to global change: details that matter?

Luc De Meester

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In most studies on aquatic systems and their responses to climate change or their management, we tend to totally ignore intraspecific trait variation and evolutionary trait change. Studies dealing with evolutionary responses to environmental change tend to be viewed as only marginally relevant to the big picture, being about "details". The field of eco-evolutionary dynamics in this view is a hype with little added value. In this lecture I will show that ignoring interactions between ecological and evolutionary processes may strongly distort our view on how populations, communities and ecosystems respond to environmental change, and might lead to wrong predictions and management decisions. This may be especially important in relation to human-induced environmental change, as these often create novel habitats and strong selection pressures. The evolving metacommunity framework tries to disentangle the relative importance of species sorting and evolution in determining community responses to environmental gradients, both locally and regionally. Drawing on our own work on evolution in the water flea *Daphnia* in relation to environmental change, I will illustrate how populations evolve and how this evolution impacts ecology and the functioning of ecosystems. I will focus on evolutionary responses to climate change, urbanisation and toxic cyanobacteria blooms, and will present results of experiments showing how such evolutionary changes impact community composition and top-down control of algae even on very short time scales. I will then broaden the perspective to link eco-evolutionary dynamics to our capacity to predict ecological responses to global change and to our management efforts. Important concepts in the context of eco-evolutionary dynamics in nature are the race between evolution and immigration, and the fact that so-called cryptic eco-evolutionary dynamics are likely common. One aspect of cryptic eco-evolutionary dynamics is that evolution might be a key contributor to ecological stability.

Kilham Memorial Lecture: Limnology and the future of African inland waters.

Richard Robarts[1], Tamar Zohary[2]*

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Limnology as a multidisciplinary science has a major role to play in achieving sustainable solutions for Africa's water shortage and environmental problems and ensuring they are protected, conserved and maintained for future generations. Collection and provision of scientific data to

support knowledge-based management plans and policies, along with personnel training, are needed. Properly designed and implemented limnological programs are essential for realizing these objectives. We present an overview of the major stressors and current state of African inland waters and describe several major African limnological programs. We assess the reasons why these programs were scientifically successful but did not result in effective, or only limited, water management. It is crucial that future limnological programs in Africa be designed and executed to ensure that research results are transferred from scientists to decision makers in a way that they understand and can use. We propose that a Pan African Water Institute be formed in partnership with exciting new initiatives, such as the African Centre for Aquatic Research and Education (ACARE), with support of international (e.g., SIL) and participation of local limnological and other water-focused organizations. Such an entity would provide communication and coordination between regional water initiatives and government authorities. It would advocate for the implementation of sound recommendations and help ensure they were not ignored by local and national authorities, leading ultimately to a pan African water framework directive. Several international conferences on African water have recommended such an umbrella organization – it is now time to implement it.

Emerging perspectives on the role of benthic production and food web linkages in lakes.

Jake Vander Zanden[1], *Yvonne Vadeboncoeur*[2]

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[2] Wright State University, United States

In our current era of unprecedented global environmental change, studying lakes from a whole-ecosystem perspective provides a holistic basis for understanding and conserving lake ecosystems. In this talk, I'll summarize our emerging understanding of the role of benthic productivity, and its contribution to supporting higher trophic level production in lakes. Benthic primary production can be a surprisingly important contributor to whole-lake primary production, and often makes a disproportionately large contribution to higher trophic levels. Benthic productivity also plays a special role in linking lakes and the surrounding landscape through aquatic insect emergences. Studies of benthic productivity in a larger food web context is part of a larger movement to apply more holistic and whole-ecosystem approaches to the study of lakes.

Lacustrine deposit and PAGES research in China.

Ji Shen

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Lakes are normally formed under various geological and geographical backgrounds. As a component of the terrestrial hydrosphere, lakes have close relationships with the atmosphere, biosphere and lithosphere, and serve as the connection between these systems. Once a lake is formed, it is influenced by a series of tectonic, climatic and anthropogenic factors. As a result, lacustrine evolutional processes usually involve geological, physical, chemical and biological processes and the interactions between them, and these processes are all documented by lacustrine sediment archives. Because lakes are widely distributed worldwide and normally undergo a long history of evolution, lacustrine sediment generally possesses a continuous record with high resolutions that provides abundant information regarding regional environmental and climatic variations that can be used in global change studies. Lacustrine sediment also contains information pertaining to human activities, since people tend to settle around lakes owing to the resources they

provide.

From west to east, Chinese topography is characterized by the so-called “three-step ladders”, which were formed by tectogenesis. The first-step ladder is the notably uplifted Tibetan Plateau, which is circled by higher mountains containing deep canyons on the outer mountainside. The inner plateau topography consists of mountains, valleys and basins, with lakes along fracture zones. These lakes consist of saline or brine with closed or semi-closed basins and freshwater lakes with intermountain basins produced by glacier erosion or river-headward erosion. The Tibetan Plateau is very lake-concentrated, with a total lake surface area that accounts for 49.5% of that of China. Most lakes now have deep water and long histories. The Hengduan Mountains are the transitional zone of the first- and second-step ladders, and are characterized by high mountains and deep canyons with diverse elevations. Lakes of this area are often situated in steep and deep depression basins, and some are dammed lakes caused by landslides and/or debris flows. The second-step ladder is characterized by plateaus and basins caused by differential elevations of land masses, which allows for tectonically-derived depression lakes. When compared with the first-step ladder, the second-step ladder is characterized by tectonic movements with lower intensities and amplitudes. As a result the lakes on the second-step ladder usually have continuously sinking lake basins, such as Lake Dianchi, Erhai, Lugu on the Yunnan-Guizhou Plateau and Lake Daihai and Huangqihai on the Mongolia Plateau. The third-step ladder consists of the extensive plains in Eastern China and is characterized by an overall sinking topography. Lakes on this ladder are often formed by river valley migrations, such as lakes of the brooky regions in the middle and lower reaches of the Yangtze River. These lakes have shallow waters, short histories and evident disturbance by human activities.

Global Changes to Carbon and Nutrient Cycles by River Damming.

Philippe Van Cappellen

University of Waterloo, Canada

The damming of rivers represents one of the major anthropogenic disturbances of the natural cycles of water, carbon and nutrient elements on the continents. The associated changes in the environmental flows of nutrients have far-reaching ecohydrological consequences, from individual ecosystems to the global biosphere. While dam reservoirs usually act as sinks of macronutrients in river systems, their effects on riverine fluxes and chemical speciation differ markedly from one nutrient element to another. Dams thus fundamentally alter nutrient limitation patterns, trophic conditions and water quality in river ecosystems and receiving water bodies, including lakes, floodplains, wetlands and coastal marine areas. Regional and global assessments of the changes in riverine nutrient fluxes caused by the construction of dams have so far relied on empirical correction factors with limited predictive capability. By contrast, we developed a knowledge-based upscaling framework, which integrates available data on elemental budgets for individual reservoirs, mechanistic models of nutrient cycling in surface water bodies, and a stochastic analysis of model outcomes. The approach enables us to simulate the temporal changes in nutrient elimination by damming in all the major river basins of the world. Here, we illustrate the use of the modeling approach to estimate the global modifications of the riverine fluxes of organic carbon (C), phosphorus (P), nitrogen (N) and silicon (Si) by dams. Next, the results for the individual elements are brought together to assess the historical and future changes in the relative riverine delivery of P, N and Si to the world's coastal zone. A key conclusion is that damming has, and will continue, to cause global shifts in nutrient ratios discharged to the oceans, thereby changing the structure of coastal plankton communities.

Sequential impacts of climate warming on cold-water fish: From preferred habitat to behaviour and growth.

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Warming related to climate change is altering the thermal regimes of temperate lakes, with common changes including shorter periods of ice-cover and rising surface water temperatures. However, relatively little is known on how these warming-induced changes to lakes will impact fish populations. In this talk, I will use long-term monitoring data collected from lakes in Canada, to show how warming over the past 40+ years has altered preferred habitat for Lake Trout (Salvelinus namaycush), a cold-water predatory fish native to North America. I will then show how observed changes to preferred habitat alter the habitat use, diet, and growth of individual fish and inevitably translate to changes in the size-structure of the population. Together these results illustrate how the effects of warming can cascade through lake ecosystems to impact predatory fish populations through both direct and indirect avenues.

01. Phytoplankton and zooplankton ecology

01-O Ten years development of cyanobacterial bloom in Lake Poyang, the biggest freshwater lake in China.

Yuwei Chen[1], Jinfu Liu[1,2], Kuimei Qian[3], Xia Liu[1]

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Ten years bloom-forming cyanobacteria had been observed from 2007-2016 in Lake Poyang, China. Other phytoplankton biomass and related nutrients in different hydrological stages in the lake were also analysed using the seasonal monitoring data in the same period. Our results suggested that colonies of cyanobacteria were first appeared in the Eastern Bay and some separated small lakes in the southern part of the Lake, and then advected offshore by large-scale horizontal transport processes, with the colonies subsequently found in Northern Poyang Lake. Mean values of cyanobacterial biomass was 0.75 mg l^{-1}) in 2007 and increased to 2.17 mg l^{-1} in 2016. The cyanobacteria biomass in the lake was significantly increased while the dominant species of were still *Microcystis* sp. and *Anabaena flos-aquae.* The cyanobacterial bloom distribution area was also showed the increasing tendency in these ten year same as the increasing trend of nutrients concentrations. But negative correlations were observed between cyanobacteria biomass and nutrient concentrations in the Eastern Bay showed the potential for the luck of nutrients in this area. We forecast that the eutrophication process will accelerate in the coming 20 years in Lake Poyang. It must draw more attention to the local society. Sewage and pollute control shall carry out as soon as possible in the catchment of the lake.

01-O Dormant no more: when are our lakes the greenest?

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The annual peak in phytoplankton biomass in freshwater lakes occurs during the growing season - correct? If so, why are observations of high winter algal biomass becoming more common? Are the observed winter phytoplankton peaks a case of the more we look, the more we find? Or is it because winter, the un-monitored season, is changing. Winter limnology is receiving increased attention, and recent global studies report that under-ice Chlorophyll *a* concentrations (Chl*a*) are half of that measured during the summer. From a year-round perspective, this significantly challenges the assumption of negligible biomass during winter. Here, we explore winter phytoplankton peaks over a latitudinal gradient. We hypothesize that rapidly changing seasonal physical factors (i.e., light, temperature, and mixing dynamics) may be facilitating phytoplankton growth in this typically understudied season. We present year-round Chl*a* from meso- to eutrophic lakes and reservoirs in Canada and the United States. Collectively, they represent a range in ice and snow cover and some data were collected by citizen scientists. In Canada, annual Chl*a* maxima occurred during winter, under ice. These winter peaks had a higher Chl*a* than measured during the summer months. In the midwestern United States, Chl*a* in an urban Missouri reservoir peaked in winter during of the years sampled. In an additional Missouri reservoir sampled for a full year, about half of them had Chl*a* maxima in winter. In a Kansas drinking water reservoir, winter cyanobacterial blooms are associated with taste-and-odor problems. This presentation explores whether these shifting peaks are a consequence of climate-induced shorter winters, or if recent efforts to expand the seasonal sampling window are capturing previously unaccounted-for phytoplankton peaks. Understanding winter phytoplankton dynamics will be important for predicting future changes in year-round lake function.

01-O Long-term variability of the *Dolichospermum* in a river-connected floodplain lake: Poyang Lake.

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The phytoplankton community of river-connected floodplain ecosystems shows significant temporal fluctuations in response to hydrological regime. The aim of our study was to analyze the effect of the water level fluctuations (WLFs) of Poyang Lake on the inter-annual variation in *Dolichospermum*. Samples of phytoplankton were taken at the sub-surface of the pelagic zone of the lake from January 2012 to December 2016. Results showed that Cyanobacteria increased from spring and contributed significantly to the total biomass in summer and autumn, and peaked in July of 2014 with a value of 25.18%. *Dolichospermum* was the dominated species, with a mean value of 37.25% among the Cyanobacteria. Contrast with *Microcystis,* which was dominated in the Autumn and with a value of 22.6%, *Dolichospermum* was dominated in Summer. It was first generated in the Eastern Bay (EB, lentic region) and then advected offshore by largescale horizontal transport processes, with the filaments subsequently found in Northern Poyang Lake (NPL, lotic region). The *Dolichospermum* biomass also showed the increasing tendency during the investigation years same as the increasing trend of nutrients concentrations. However, significant correlation was not observed between *Dolichospermum* biomass and nutrient concentrations in Poyang Lake. Statistical analyses showed the great influence of water level on seasonal succession of *Dolichospermum* through alternations of underwater light availability and dilution nutrients. High water level generally with low nutrients and high underwater light availability, which was in favor of the growth of *Dolichospermum*. Whereas, low water level usually creates an instable and low underwater light availability condition, which isn't conducive to *Dolichospermum* growth. This study revealed that hydrological parameter dominated the accumulation of *Dolichospermum*

blooms in the river-connected floodplain lake.

01-O Spatial and Temporal variations in phytoplankton species composition in the near shore Tanzanian waters of Lake Tanganyika.

A.S. Mbonde, A.N.M. Kalangali, I.A. Kimirei

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Phytoplankton population in Lake Tanganyika was monitored for five years since 2013 to assess changes in species composition and distribution. Water samples were concentrated by towing a phytoplankton net of 13 µm pore size vertically from 100m to the surface. The samples were fixed using the alkaline Lugol's solution and later observed under an inverted microscope at a 400x magnification, and phytoplankton identified to species level (whenever possible) using various identification manuals. A total of 105 phytoplankton species were identified with diatoms (Bacillariophyceae) dominating (63.64%) the phytoplankton population throughout the sampling period, followed by Cyanophyceae (15.89%), Chlorophyceae (10.75%), Euglenophyceae (4.71%), Dinophyceae (4.58%) and Chrysophyceae (0.42%). Indicators of inorganic pollution like *Microcystis* and *Anabaena* species were rare, while *Nitzschia, Navicula, Surirella*, and *Oscillatoria* (indicators of oligotrophy) were abundant. Significantly more phytoplankton (mainly diatoms) were encountered during the dry season both for offshore and inshore sites. However, the highest phytoplankton abundance was recorded in the coastal waters (>80%) with the Luiche river mouth contributing about 40% of all Phytoplankton abundance. Cyanobacteria peaked in October than in all other months. The phytoplankton composition observed during this study resembles that of the early 1900s which depict the oligotrophic environment in the lake. However, the increased phytoplankton abundance in the inshore waters (as compared to offshore waters) indicates signs of nutrient pollution and therefore calls for more research attention.

01-O Eutrophication or climate change? Long-term decrease in the efficiency of trophic coupling between phytoplankton and zooplankton - a causality analysis.

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Lake Stechlin was an oligotrophic dimictic lake up to the end of the 1990s. Then, the lake underwent an apparent eutrophication shown e.g. by increase of heterocytic cyanobacteria, but without increase in external P loading. Meantime, it was explored that the lake is especially sensitive to extreme weather events signalling climate change. Here, we analyzed long-term trends (1994-2014) of phytoplankton and zooplankton with the aim 1) to investigate whether long-term trends do occur in the functional community structure of phytoplankton and zooplankton and if so, how they affect zooplankton in the lake; 2) to assess how resource use of these two compartments of the planktonic food-web changes and 3) to find out if the observed changes are attributable to climate change or result only from accidental deliberation of internal P reserves. According to the results, increasing dominance of filamentous cyanobacteria was paralleled by decrease of large sized zooplankton species. Resource use efficiency of phytoplankton (phytoplankton biomass/TP ratio) increased over time, while that of zooplankton (zooplankton carbon/phytoplankton carbon)

decreased. Reverse trends in the ecosystem functioning of phytoplankton and zooplankton may suggest a trophic decoupling between these groups with potentially decreased efficiency towards higher tropic levels. The causality analysis involved the purely climate dependent relative water column stability (RWCS), TP, phytoplankton carbon (C1), zooplankton carbon (C2) and planktonic carrying capacity (CC = C1+C2). Causality analysis selected RWCS as master variable that initiated a cascade of changes affecting especially C2 and CC with feed backs between TP, C1, C2 and CC. The delay between change of RWCS and the biologically determined variables was found to be some 200 days, which is in line with the overturn periods of this dimitcic lake. Our study revealed that changes stratification properties (strength, length) may trigger changes of the internal P metabolism of a lake which may result in internal P load with consequences on compartments of the pelagic food web.

01-O Warming and Salt Intrusion Affect Microcystins Production in Tropical Bloom-Forming *Microcystis.*

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Southern Vietnam including the Vietnamese Mekong Delta is predicted to be one of the regions most extremely impacted by climate change, causing increased temperature and salinity in water bodies located 40 – 50 km upstream from the mouth of Mekong river in the delta. We hypothesised that the increase in temperature and salinity may impact the microcystin production of two *Microcystis* strains isolated from water bodies in this region. These two *Microcystis* strains were grown at low (27˚C), medium (31˚C), high (35˚C) and extremely high (37˚C) temperature in flat photobioreactors (Algaemist). At each temperature when the cultures reached a stable state sea salt was added to increase salinity to 4, 8, 12 and 16‰. Two-way ANOVA indicated that there was a significant temperature effect, a significant salinity effect and a significant temperate x salinity interaction on microcystin production in the two *Microcystis* strains. Microcystin concentrations were significantly reduced at medium and especially at high and extremely high temperatures. Salinity, in general, had comparable effects on microcystin concentrations at different temperatures. At the salinity of 4 and 8‰ concentrations of microcystin per mL of culture and microcystin per cell quota (based on chlorophyll, dry-weight and cell counts) were higher than at 0‰, while at the highest salinities (12 and 16‰) these were strongly reduced. In one strain, however, there was no effect of salinity on microcystin concentrations and cell quota, but in this strain the temperature effect was very strong and concentrations were already reduced drastically. Overall, higher temperature led to lower microcystin concentrations and cell quota, low salinity seemed to promote microcystin production and high salinity reduced microcystin production. Hence, increased temperature and higher salinity could lead to less toxic *Microcystis*, but since these conditions might favour *Microcystis* over other competitors, the overall biomass gain could offset a lower toxicity.

01-O The temporal coherence of lake phytoplankton community composition across a regional set of lakes.

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In recent years, freshwater ecology has moved away from a focus on the temporal dynamics and stability of single water bodies towards a greater understanding of multiple regional systems. Part of the reason for this shift is the recognition that many lake problems and processes are regional, or even global. A useful concept for understanding the dynamics of ecosystem change in a regional context is 'temporal coherence', or the degree to which change in limnological variables is temporally synchronous across multiple lakes. Strong temporal coherence in phytoplankton communities among lakes in a region may reflect control by drivers such as regional climate. In contrast, low coherence could occur when local-scale regulators are more important. In this study, 10 years of water quality and phytoplankton biovolume data on seven lakes in New Zealand were used to explore temporal coherence of lake phytoplankton communities. Four groups of environmental factors spanning local to regional scales were also examined: water quality conditions; morphological features of lakes (e.g. depth); catchment land uses; geographical distances among lakes. We identified a weak temporal coherence in phytoplankton community compositions across the seven lakes, which was significantly related to the lake-specific temporal variations of water quality conditions. The degree of coherence in water quality conditions significantly explained over 46% variance of the temporal coherence of phytoplankton community compositions across study lakes. The weak coherence in both water quality conditions and phytoplankton community composition suggest that it is not possible to use information from one lake (e.g. variations of water quality conditions or phytoplankton community compositions) to predict the dynamics of another lake in the study region.

01-O Survey on vertical and lateral variations of *Aphanizomenon* in a water body.

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The spread of harmful algal blooms (HABs) is a global issue due to temperature increases that are attributed to climate change and the inflow of pollution sources due to industrial development. Each summer, harmful algal blooms are a big issue in Korea for many reasons. Although harmful algal blooms are a natural phenomenon that occur when conditions in a waterbody are adequate, there are several concerns related harmful algal blooms such drinking water safety and recreational use of water.

In this study, we surveyed variations of *Aphanizomenon* populations, a type of blue-green algae that causes harmful algal blooms in reservoirs and streams. *Aphanizomenon* is known for producing odorous compounds and toxins. The study areas were the Nakdong River and Namkang reservoir including the lower section of the Namkang area. The lower section of the Namkang included seven sites for studying lateral variations of *Aphanizomenon*. Also, the concentrations of nutrients were surveyed to review the effects of nutrition materials that cause harmful algal to expand and bloom.

In the results, *Aphanizomenon* showed the typical vertical migration day and night. The highest concentration of *Aphanizomenon* occurred around noon and decreased gradually in the later part of the afternoon. Also, at a depth of 5m from the surface, vertical variations occurred in the *Aphanizomenon* concentrations. However, there were no variations of *Aphanizomenon* concentrations at a depth of 5m to the bottom in the Namkang reservoir. In the tributary of Namkang, there were variable concentrations of nutrients and algal populations. Point sources of contamination from large urban centers caused the increase of phytoplankton population following nutrients levels. In conclusion, the understanding of vertical and lateral variations of blue-green algae, *Aphanizomenon*, provides better decision making for water quality management in waterbodies.

01-O Temporal dynamics of photosynthetic picoeukaryotes in Lake Chaohu, revealed by flow cytometric sorting and high-throughput sequencing.

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Picophytoplankton is the phytoplankton with the cell size less than 3.0 μm, and is widely distributed in marine and freshwater ecosystems around the world. Photosynthetic picoeukaryotes (PPEs) is abundant in lakes with relatively high nutrient concentrations. Furthermore, their composition is highly complicated and diversified. The monthly diversity and composition of photosynthetic picoeukaryotes (PPEs) in Lake Chaohu, were investigated through a whole year, by combining flow cytometric sorting and high-throughput sequencing. Sequencing results showed that PPEs were distributed in all of known phylum, and were dominated by Chlorophyta and Bacillariophyta, which accounted for 70% of all PPEs sequences. At the high classification level (phylum or class), the community composition of PPEs was relatively stable throughout the year. However, three temporal succession patterns for PPEs composition structure were observed at OTU level. Firstly, OTU134 affiliating to *Neochlorosarcina negevensis* was evenly appeared in all of the months. Secondly, OTUs belong to Sphaeropleales and Bacillartiophta showed seasonal change patterns, e.g. OTU1 (*Stephanodiscus hantzschii*), OTU189 (*Monoraphidium convolutum*), OTU8 (*Pseudoschroederia antillarum*). Thirdly, Most of OTUs affiliating to Chlamydomonadales and Chrysophyceae, changed within months. Temperature and nitrate concentration was the major environmental factors to influence the community structure of PPEs. The relationship between PPEs and its associated heterotrophic picoeukaryotes was analyzed by molecular ecology network. The analysis results indicated that OTUs which was selected as nodes in ecological network with high degree were almost completely different from those OTUs which were retrieved abundantly. Most of node OTUs were related to Chlorphyta and fungi, and they had negative relationship. In addition, seasonal ecological network analysis results showed that the number of module increased, but the connectivity of module decreased.

01-O Spatial heterogeneity of spring phytoplankton in a large tropical reservoir - Could mass effect homogenize the heterogeneity by species sorting?

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Reservoirs are river-lake hybrid ecosystems characterized by a marked longitudinal zonation and variable flushing rates depending on the use of stored waters. The structure of their phytoplankton is therefore subjected to the interplay between the environmental conditions of the different zones (species sorting) and the strength of the unidirectional flow (mass effect). The spatial distribution of spring phytoplankton was investigated in a tropical reservoir across its different zones. Phytoplankton displayed heterogeneous spatial patterns from the turbulent, nutrient rich riverine zones to the relatively stable lacustrine zone. The analysis of this spatial heterogeneity revealed the relative importance of species sorting and mass effect in this morphologically complex reservoir. Different taxonomic groups showed different spatial patterns due to their specific physiological and morphological features, and as a result of the local environmental filtering. In the studied reservoir, the strength of the homogenizing effect of water flow did not smooth the spatial heterogeneity and played a weak role in constraining spring

phytoplankton. Actually, water flow contributed to the spatial heterogeneity of phytoplankton by enhancing the local environmental differences caused by an operational drop in water level, and species sorting resulted as the primary forcing in determining spring phytoplankton spatial distribution.

01-O Effects of algae growth on the characteristics of water and cadmium in Taihu Lake.

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To investigate the effects of algae growth on environmental conditions (pH, dissolved oxygen, the redox potential) and the migration of Cd from sediment to water, the indoor simulation experiment were conducted with laboratorial microcosm (*M. aeruginosa*) and sediment from Taihu Lake. The results showed that pH and DO concentration of overlying water increased and the redox condition of surface sediment (0-2 cm) was changed from weak oxidation to weak reduction by *M. aeruginosa* growth. These changes of environmental conditions enhanced the cadmium (Cd) mobilization from sediments to overlying water. The dissolved Cd concentration in overlying water can be decreased during algal growth process due to the absorption by *M. aeruginosa*. The results of this study indicated that algae growth would decrease the metal Cd speciation, and also could effectively reduce the ecological risk of total Cd in sediment according to the I_{geo} and E_r^i .

01-O Nitrogen fixation by the cyanobacterium *Raphidiopsis raciborskii*: Modelling reveals relationships with extracellular nitrogen supply.

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Raphidiopsis raciborskii, basionym *Cylindrospermopsis raciborskii* is responsible for harmful cyanobacterial blooms that are increasing in extent and frequency across the globe. *R. raciborskii* has recently increased in biogeographical range from the tropics and subtropics to the temperate zone. It has the ability to grow under low-nitrogen environments through the ability to fix atmospheric nitrogen. Nitrogen fixation by *R. raciborskii* is regulated by the formation and loss of heterocyst cells. Our previous experimental work has have shown that nitrogen fixation is energetically costly such that while it is advantageous in low-nitrogen environments, it also reduces growth rates. We used laboratory experiments to inform the development of a model for *R. raciborskii* growth, including the process of nitrogen fixation by heterocyst cells. The model is written in the computer language R and can easily be expanded to include phosphorus dependency and additional phytoplankton species. Here we explored different nutrient regimes using the model, for instance increasing or decreasing nitrogen concentrations and effects of pulsed nitrogen supply, as well as the specific environmental conditions that could lead to its dominance. Combining knowledge gained from laboratory studies and numerical models has informed our understanding of the competitive advantage provided by nitrogen fixation in *R. raciborskii* and sheds light on the reasons for its expanding range across the globe.

01-O Development of a new acoustic method for quantification and monitoring of the bloom-forming cyanobacterium *Microcystis.*

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Microcystis is one of the key bloom-forming cyanobacterium in many eutrophic lakes and reservoirs worldwide, which poses a serious threat to environmental safety and public health. Efficient *in situ* monitoring methods are required to study and predict the *Microcystis* bloom development. In this study we suggest an acoustic method to quantify abundance of gas-containing *Microcystis* colonies using a Simrad scientific echo sounder EY60 operated at 200 kHz in both a tank experiment and Lake Dianchi. In a large tank a high correlation between volume backscattering strengths (S_v) and chlorophyll *a* (Chl_*a*) concentration, as a proxy of *Microcystis* biomass, was found. The detection limit for *Microcystis* concentration was ~1.7 mg Chl*a*/L. The obtained acoustic signal was also significantly correlated with biovolume of *Microcystis* colonies measured by the FlowCAM® systems and Laser In-situ Scattering and Transmissometry (LISST-200x). We implemented this method for *in situ* monitoring of *Microcystis* bloom in Lake Dianchi (China) and showed a good agreement between the acoustic signal and Chl *a* concentration at each sampling time. The relationship between S_v and Chl *a* concentration was slightly changed during 24 hours and may reflect the variation the proportion of free gas in the *Microcystis* colonies at different light intensities. In general, the 24-h acoustic monitoring reviled the vertical and temporal variability of *Microcystis* biomass at a sampling station. Our study showed great efficiency of the acoustic methodology for real-time monitoring of *Microcystis* bloom and assessment of vertical distribution of the cyanobacterium in the water column. The methods showed its effectiveness even at early stages of bloom development.

01-O Invasive lake snow: near pristine glacial lakes transformed by a nuisance, mucilage secreting planktonic diatom, *Lindavia intermedia.*

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New Zealand's South Island is world-renowned for its ultra-oligotrophic, alpine, lakes and rivers. In 2004, the invasive pennate diatom *Didymosphenia geminata* began to colonise many South Island rivers prized for their world-class trout fishing. This diatom can smother river beds with abundant secretion of long polysaccharide stalks and, within a decade, had spread to oligotrophic rivers throughout the South Island. At around the time that d. *geminata* was spreading, a pelagic slime was reported by fishers in Lake Wanaka (A_o = 192 km^2, Z_{max} = 311 m). This was identified as lake snow, a globally rare phenomenon in lakes, which appeared to be associated with *Lindavia intermedia*, a centric diatom previously unreported in the lake. The macroaggregates foul fishing lines, coat swimmers, and clog motorboat cooling systems, preventing enjoyment of the lake. Lake snow also clogs domestic and industrial water filters in Wanaka Township (pop. 7,850), which takes its water from the lake. Its effects on the aquatic ecosystem remain unknown. Since its detection in Lake Wanaka, surveillance of other lakes shows that *L. intermedia* has spread widely throughout New Zealand. While *L. intermedia* is found

across the trophic gradient, macroaggregates are found almost exclusively in oligotrophic lakes in which the diatom occurs.

Palaeolimnological analysis did not detect frustules of *L. intermedia* in sediments older than around the year 2000 in Lake Wanaka. Population genetics of *L. intermedia* from lakes in New Zealand, Washington State (USA), British Columbia (Canada) and Switzerland indicated that all lake snow producing populations (from New Zealand and Lake Youngs, Washington State) are very closely related. We hypothesize that both *L. intermedia* and d. *geminata* arrived on the South Island from the west coast of the United States around the year 2000, with the most likely vector being a tourist fisher's felt-soled waders.

01-O Effect of rotifer density on clearing *Phaeocystis* decreases with rising temperature.

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Due to sea water eutrophication and global warming, the harmful *Phaeocystis* blooms outbreak frequently in coastal waters, which cause a serious threat to aquatic ecosystem. The application of rotifer to control the harmful alga is a promising way. To investigate the influence of initial rotifer density and temperature on the ability of *Brachionus plicatilis* to eliminate *Phaeocystis globosa* population, we cultured *P. globosa* with different initial rotifer densities (1, 3, 5 inds mL^{-1}) or without rotifer at 19, 22, 25, 28, and 31 °C for 9-16 days. Results showed that higher temperature favors the growth of *P. globosa* and *B. plicatilis*. The rotifer population increased rapidly based on the *Phaeocystis*. With increased initial rotifer density and temperature, both the clearance rate of rotifer and the reduction rate of *P. globosa* increased, and thus *P. globosa* were eliminated earlier. Both the temperature and initial rotifer density had significant effects on clearance rate of rotifer and the time to *Phaeocystis* extinction, and there was a significant interaction between the two factors on the two parameters, i.e. the effect of initial rotifer density on eliminating *Phaeocystis* decreased with increasing temperature. The rotifer in 5 inds mL^{-1} at 28 °C eliminated *P. globosa* in 4 days, whereas the rotifer in 1 inds mL^{-1} at 19 °C spent about 16 days on eliminating *P. globosa*. In conclusion, higher temperature and bigger initial rotifer density promote rotifer to eliminate the harmful *P. globosa*, and the optimal temperature for rotifer to clear *P. globosa* is 28 °C.

01-O Estrogenic effect of *Microcystis aeruginosa* exudates on *Daphnia magna*.

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Cyanobacteria are widespread organisms which draw attention due to their mass expansion in many eutrophic lakes. Recently, some cyanobacteria species have been found to have estrogenic effects on aquatic animals. Zooplankton play important roles in aquatic ecosystems, and their responses to environmental changes are important since they will affect the stability of the foodweb. In order to explore the estrogenic effect on zooplankton of *Microcystis aeruginosa*, a dominant cyanobacteria species in many systems, we assessed the reproductive biology of of *Daphnia magna* exposed to two levels of *M. aeruginosa* exudates (MaE, $2x10^4$ cells/ml and $4x10^5$ cells/ml). MaE at low and high concentrations promoted the total amount of eggs (15.4% and 23.3%, respectively) and total number of young (37.7% and 52.4%, respectively) of d. *magna*, which was similar in effect to exposure to 10μg L^{-1} estradiol. In addition, both concentrations of MaE contributed to the intrinsic rate of increase (7.5% and 3.0%, respectively) and net

reproduction rate (17.3% and 31.3%, respectively) of d. *magna*. This study verified the estrogenic effect of cyanobacteria on zooplankton and provides a scientific basis for prevention and control of cyanobacteria blooms. Additional studies are currently underway to further explore these estrogenic effects of MaE on physiological, biochemical and molecular characters of d. *magna*.

01-O Environmental correlates to cyanotoxins in tropical lentic waters.

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Microcystins (MC) and Cylindrospermopsins (CYN) are among toxins produced by certain cyanobacteria that occur naturally in fresh waters. A comprehensive 12-month survey of 17 tropical reservoirs was conducted from November 2012 to October 2013, using a LC-MS/MS quantitative analysis method developed to target multiple toxins. The most prevalent MC variants identified were MC-RR and MC-LR. Based on random forest (non-parametric decision trees) analysis, total rainfall and total nitrogen concentrations were found to be the most important environmental factors influencing total MC concentrations. Total rainfall was found to be more important than total nitrogen concentrations with higher rainfall correlating to higher MC concentrations. This could imply that elevated rainfall may increase nutrient runoff into these tropical reservoirs which could lead to increases in cyanobacterial biomass. The most important environmental factors influencing CYN concentrations were total nitrogen, nitrate, total phosphorus concentrations and Cylindrospermopsis counts. Total nitrogen concentrations were found to be more important than nitrate and total phosphorus concentrations and Cylindrospermopsis counts, with higher total nitrogen concentrations correlating to higher CYN concentrations. Our findings indicate that reducing total nitrogen concentrations may be useful in minimizing cyanotoxin concentrations in tropical lentic bodies.

01-O Towards a trait-based understanding of zooplankton effects on cyanobacterial dominance.

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While top-down control of phytoplankton by zooplankton is a cornerstone of aquatic ecology, cyanobacterial blooms often support high zooplankton biomass, raising questions whether zooplankton might facilitate rather than control cyanobacteria. In a series of laboratory experiments, we asked how zooplankton with contrasting grazing traits (i.e., grazing mode and behavior) controls the abundance of cyanobacteria (*Microcystis* or *Cylindrospermopsis*) and eukaryotic phytoplankton (*Cryptomonas*) co-cultured in artificial food webs over 4-7 days. We hypothesized that selectively grazing copepods would facilitate cyanobacterial dominance while generalist cladocerans would not. We also hypothesized that among copepods, facilitation of cyanobacterial dominance would be stronger in a raptorial cyclopoid compared to a filter feeding

calanoid. The relative growth and abundance of co-cultured phytoplankton was compared in the presence or absence of each grazer. Experiments started with a 6-9 fold initial dominance of *Cryptomonas* over cyanobacteria by biomass. As predicted, the generalist grazer *Daphnia* had no effect on the competition between cyanobacteria and eukaryotic phytoplankton while selective copepods facilitated the dominance of the former. Copepod promoted cyanobacterial dominance persisted longer with the raptorial cyclopoid than a filter feeding calanoid due to strong prey-switching in the latter. The results emphasize the role of zooplankton grazing traits (e.g., selective vs. generalist, raptorial vs. filter feeder) as potential regulators of HABs.

01-O Interactive effects of genotype and food quality on consumer growth rate and elemental content.

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How does consumer elemental composition evolve? In this study, we examined the evolution of *Daphnia* body phosphorus (P) content, its relationship with other life-history traits (growth and P use efficiency), and its ecological consequences. We did so by collecting unique *Daphnia* genotypes from 2 species in natural populations spanning a regional P gradient and raising them across laboratory P gradients. In general, we found that consumer intra-specific trait variation was comparable to inter-specific variation. Daphnid body %P was highly plastic, but little of this variation had a genetic origin. *Daphnia* growth was also highly variable, but a large portion of this variation was related to daphnid genotypes. In contrast to previous stoichiometric studies, relationships between daphnid body %P and growth were nonlinear and relatively weakly related indicating that selection acting on growth might not explain body %P evolution in these populations. Instead, *Daphnia* P use for growth (PUE) showed strong genotype x environmental variation indicating that selection acting on efficiency as opposed to growth could explain the evolution of body P content in our study lakes. Daphnid PUE also appeared to explain regional species distributions with the species found in lower nutrient lakes showing higher mean PUE. Overall, these results suggest that consumer elemental composition is controlled by both environmental P concentrations and population genetic variance and furthermore that variation in either of these variables could have significant eco-evolutionary consequences in natural populations.

01-O Ground water biology: A new and fascinating area of basic research in India.

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Ground water biology is a multi-disciplinary subject especially dealing with subterranean fauna, progressed more slowly than other branches of limnology. Progress in this domain has been impeded due to several factors among few contributions deal by congress of limnology compared to ecology of lotic and lentic ecosystems. Cave ecosystem is sub-discipline of ground water ecosystem is quite complex, supporting highly diversified and significant life forms, ranging from bacteria to crustaceans to fishes, and includes many unique creatures. Paradoxically, however, the Indian caves have received but little attention from the standpoint of biodiversity. However, the fellow biospeleologist in the West have already made rapid strides in this area. They are presently engaged in advanced research involving evolutionary biology in which caves have been recognised as natural laboratories

This presentation is meant to highlight the work done by us until now on the Indian caves and other hypogean aquatic ecosystems, which are not only treasure troves of unique and diverse biota, but also support several microbes that have potential clinical implications, and to kindle

interest in budding scientists about the all-important biodiversity studies. Furthermore, to understand as to how the cavernicoles could establish themselves as a distinct community despite the extreme limitations of space, food, light, etc., posed by the cave environment is indeed a challenge before the present day biologists.

01-O Large and diversified population dynamics of *Daphnia pulex* in response to multiple predation cues.

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Individual defense responses to predation cues are well-studied. However, the individual characters linking population dynamics in response to predation cues are less well understood despite its important role in shaping structure and functioning of the ecosystem. In the present study, we investigated the individual characters linking population dynamics of *Daphnia pulex* in response to multiple cues from fish predation. Two clones of d. *pulex* (ZJ clone and DL clone) population were raised under multiple predation cues treatments (alarm signal (A), kairomone (K), and the combination (KA)) until 13 days after the populations reached carrying capacity. Individual responses on morphology and life history were recorded, additionally, the parameters of population dynamics including the population growth rates, carrying capacity, average size, age structure, dormant eggs, and grazing rates were calculated. Our results revealed that both clones perform a same response to K and KA in both individual and population levels. Evidently, the population dynamics were highly linked to the individual characters: the predation cues could cause a synergetic effect on ZJ clone by combining the life history and morphological changes, which ultimately evoke reduced individual weight by a maximum of 39.1% and increased carry capacity by a maximum of 75.0%. Furthermore, the decreased mutual interference in the multiple cue treatments supported the population to reach a higher carrying capacity. On the other hand, clone difference was widely observed on the individual characters linking population dynamics. Specifically, the combined effect of KA revealed that DL clone produced more dormant eggs while ZJ clone increased the carrying capacity greatly by 30.8%. In conclusion, our results demonstrated that different individual characters linking population dynamics were involved in response to multiple fish predation cues, which ultimately support larger and more diversified responses to defend against predation.

01-O Effects of filter-feeding planktivorous fish and cyanobacteria on structuring the zooplankton community in the eastern plain lakes of China.

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To explore the changes of the zooplankton community in response to excessive interferences of anthropogenic eutrophication and aquaculture on aquatic ecosystem, we performed a survey to determine the variations in these communities in 100 eastern plain lakes of China in summer. Our results showed that when filter-feeding planktivorous fishes were in high yield, Rotifera and medium cladocera accounted for a large proportion of the community; when they were in low yield, small cladocera increased with the increased nutrient level. The detrended correspondence analysis demonstrated that planktivorous fish and cyanobacteria were important factors influencing the zooplankton community. The linear regression analysis showed that the fraction of Rotifera increased and Calanoida decreased with the increasing fish yield; the fraction of small cladocera increased with the increasing cyanobacteria. The results implied that zooplankton

community succession was strengthened by the combined effects of planktivorous fish and cyanobacteria. The effects of filter-feeding planktivorous fish on zooplankton depend on the survivalability of different zooplankton species as well as the size. With the combined effects of planktivorous fish culture and eutrophication, the zooplankton community tend to be dominated by r-strategy species and good escape ability species.

01-O Potential impacts of a water conservancy project on crustacean plankton communities at river-connected lakes.

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In China, over one hundred of lakes were connected with Yangtze River before the 1950s, while, for now, only Lake Poyang and Dongting, which is respectively the largest and the second largest freshwater lake in water surface, are still naturally connected with Yangtze river. For this decade, the argument of building a water conservancy project at the outlet of these two lakes was launched by the local government. Supporters argue that impoundment, channelization, and other regulatory processes are beneficial for flood control, electrical power generation, water storage, navigation, and recreation. While opponents believe that cut off the connection of lakes with Yangtze river could result in algal blooms and the decrease of biodiversity. However, data on community and distributional patterns of crustacean plankton in these two ecosystems are almost entirely absent, and lesser were known about the potential impacts of the water conservancy project on them. Our principal objectives were to determine (a) whether crustacean plankton assemblages are significantly different in lakes with quite different hydrological regimes, (b) potential effects of a water conservancy project on crustacean plankton communities of river-connected lakes.

In this study, we conducted an analysis of crustacean community based on both wet and dry season`s data in Lake Dongting, Poyang and Junshan. The Lake Junshan was separated from Poyang floodplain by a dam, which was selected to test variation of planktonic crustaceans after building of the dam. To obtain crustacean plankton sample, two sub-surface water samples at 0-1 m depth, were obtained using a 5 liters (l) hydrophore and the samples (10 l) were filtered through a 64-μm mesh net, and preserved in 50 ml Polyethylene plastic bottles with 4% formaldehyde solution. The zooplankton were identified to genus level and counted under a dissecting microscope (at × 40-100 magnification). Water temperature, pH, conductivity, Secchi depth, chlorophyll a (Chl *a*), total nitrogen (TN) and total phosphorus (TP) were measured according to standard methods.

Comparison of crustacean assemblages was conducted respectively within Lake Poyang, Dongting and Junshan, during wet and dry seasons. Our findings suggested that planktonic crustacean community in river-connected lakes was remarkably similar to that in a river ecosystem. Nauplii, *Bosmina* spp., and cyclops, who dominating riverine habitats, were found dominating our river-connected lakes. However, in Lake Junshan *Daphnia cucullata* and *Bosmina spp* are dominant species during the dry season, *Bosmina spp, CerioDaphnia spp* and *Diaphanosoma spp* are dominant species during the wet season, Copepods nauplius and copepodids are dominant species during the whole year. In river-connected lakes, the abundance of cladocerans was higher than that of copepods only in the seasons with high water levels and slow water velocity. On the other side, the crustacean abundance in the wet season was 50 times higher than that during the dry season. During the wet season, the crustacean biomass of Lake Poyang was respectively 1.9 times and 1.5 times higher than Lake Dongting and Junshan. Lake Poyang has higher biomass and densities than Lake Dongting both in wet and dry season, even Lake Dongting has higher eutrophication levels. During the dry season, the crustacean biomass Lake Poyang was respectively 4.4 times higher than Lake Dongting, but 0.006 times lower than Lake Junshan.

Habitat types in Lake Dongting and Junshan was relatively simple: the hydrological regimes in Lake Dongting were the strongest and in Junshan Lake was the weakest of these lakes. The analysis of similarity on crustacean`s community showed that the composition has a significant difference between each other, especially for the dry season. Habitats diversities other than inter-lake environmental variables were proved to be accounted for crustacean individual abundances in our study. Littoral habitats diversity, improved by large water surface area, in favour of larger densities of crustacean to occur. Nutrients concentrations, however, showed negative correlations with crustacean standing crops when habitats were diversity and showed positive correlations with crustacean standing crops only when habitats were simplex. We evaluate impacts of water conservancy project on crustacean plankton community of river-connected lake based on its effects on hydrological variation. Firstly, seasonal water level variation which significantly impacts crustacean community in river-connected lakes will be weakened. The amplitudes of water level between wet season and dry season were respectively 13m, 7m, and 3m in Lake Dongting, Poyang and Junshan. Secondly, in river-connected lakes, allochthonous sources from floodplain zones may be an additional food source for part of the crustacean zooplankton taxa. While plenty of floodplain zones will disappear after building of a conservancy project. Thirdly, habitat heterogeneity alone is a key driver of zooplankton total biomass and functional evenness in river-connected lakes. To our study objects, expanding water surface, from dry season to wet season, improved the diversity of littoral habitats, enabling larger densities of crustacean to occur. Therefore, after building of a conservancy project, total crustacean biomass may be increased continuously with residence time.

01-O Place in space - spatial vs vertical factors influencing zooplankton (Crustacea, Rotifera) communities.

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Factors that influence plankton distribution in lakes are currently widely debated. The primary objective of our studies was to determine a combination of factors that influence three-dimensional distribution patterns of rotifer and crustacean communities in pelagic ecosystems. We compared abiotic (temperature, oxygen, nutrients) and biotic (phytoplankton) factors affecting the spatial and vertical distribution of zooplankton in different habitat conditions. We have found that in harmonic lakes vertical gradient of environmental conditions is much more important for microcrustaceans, whereas Rotifera showed strong spatial autocorrelation connected with differences in trophic status. Generally, large zooplankton prefers cold darker waters of the metalimnion-hypolimnion, while smaller species prefers warm epilimnion. This niche segregation in water profiles promotes a large diversity of pelagic zooplankton in harmonic lakes. Moreover, the vertical distribution of herbivorous zooplankton (*Daphnia* spp.) was strongly related to the phytoplankton distribution.

On the other hand, we have found that relatively productive humic (dystrophic) lakes do not offer many niches for zooplankton because of the sharp thermal gradient which results in a shallow layer of oxygenated waters. Our study suggests that different taxonomic groups of zooplankton in humic lakes are determined by a different set of environmental variables. This phenomenon together with the narrow layer of oxygenated water explains the low species richness in humic lakes. We concluded that sharp thermal gradient from the surface may reduce the biomass of herbivores, which could promote the development of phytoplankton.

01-O Long-term changes of ephippial densities of *Daphnia* species in the sediment of isolated lakes of Poyang-Junshan Lake and its correlation with the nutrients.

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In this paper, long-term changes of ephippia (or resting eggs) of *Daphnia* species in the sediments (0-36 cm) of Lake Junshan, the typical isolated lake from Lake Poyang, were studied. The ages of the 36 cm sediments at 1# and 2# sampling points are in 1839 and 1857, respectively. Before 1958, the accumulation rate of the sediment core in Lake Junshan showed a high level, but it obviously reduced after the dam was built in 1959. Before 1958, total nitrogen and total phosphorus contents in the sediments of Lake Junshan were relatively stable. However, the total nitrogen content showed obviously increasing trend after the dam was built. In the sediment of Lake Junshan, three *Daphnia* species (d. *galeata*、d. *pulex* and d. *similoides sinensis*) were identified. The accumulation rates and densities of both total ephippia and ephippia containing resting eggs in three *Daphnia* species showed a similar change pattern in the 1# and 2# sediments. Before 1958, the accumulation rates and densities of both total ephippia and ephippia containing resting eggs in three *Daphnia* species were at low levels ($0\sim1.51\times10^3$ ind./(m^2·y) and $0\sim0.22$ ind./(g·dw)); After the dam was built in 1959, the accumulation rates and densities of both total ephippia and ephippia containing resting eggs in three *Daphnia* species in the 10-1 cm sediments showed a gradual increasing trend, especially in the sediment layers of 3-1 cm (2009-2015). Pearson correlation showed that there were significant relationships (P <0.01) between total nitrogen (TN) content and the accumulation rates of both total ephippia and ephippia containing resting eggs in three *Daphnia* species in the 1# sediment score. There were significant relationships between total nitrogen (TN) and total phosphorus (TP) contents in the 2# sediment core and the accumulation rates of total ephippia in three *Daphnia* species (P <0.05). Significant relationships (P <0.05) between both total nitrogen (TN) and total phosphorus (TP) contents and the accumulation rates of ephippia containing resting eggs of d. *similoides sinensis* in the 2# sediment core were also observed. The results suggested that long-term changes of the nutrient contents and ephippia (or resting eggs) of *Daphnia* species in the sediment core could reflect the historical evolution of eutrophication and *Daphnia* populations in lakes.

01-O Exposure of *Daphnia* to environmental concentration of pharmaceuticals results in impact on their biology.

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Pharmaceuticals have become significant environmental pollutants in aquatic ecosystems. Chemotherapeutics used in cancer treatment are found in freshwaters at low concentrations (in the range of ng L^{-1}) and can be toxic or mutagenic to aquatic organisms.

The aim of the present study was to investigate the influence of the alkylating anticancer agents, cyclophosphamide and cisplatin, on three *Daphnia* species d. *magna*, d. *pulex* and d. *pulicaria*. Changes in life history parameters, such as growth rate, age and size at first reproduction, neonates number at first reproduction, and protein profiles measured with mass spectrometry, were detected in all these species exposed to these medicines. Additionally, we observed modifications in proteome among *Daphnia* males.

The disturbance caused by pharmaceuticals contaminating freshwater ecosystem is probably weaker due to the high dilution of these substances in the water, however, long time contact of

organisms with these contaminants may lead to changes on the organismal and molecular levels with unpredictable significance for the entire ecosystem.

01-O Cladocera and Copepoda Online fact-sheets presenting 158 Norwegian inland water species.

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Fact-sheets presenting 80 species of Cladocera and 78 species of Copepoda (14 Calanoida, 36 Cyclopoida and 28 Harpacticoida) are now available in Species online (https://www.artsdatabanken.no/Pages/231126), the Norwegian Biodiversity Information Center's service for information on species. Nearly 100 years ago the zoologist G.O. Sars described 74 and 63 species of respectively cladocerans and copepodes based on his detailed study of these groups. Since then we have collected information on the species composition from more than 3300 water-bodies in Norway. Despite this big effort only a few species are new compared with Sars'findings. The fact-sheets are produced both in English and Norwegian languages and include a drawing or a picture of each species. You will also find some key notes about their morphology, ecology and distribution. Further we present a map showing their distribution in Norway that will be continuously updated. We also present graphs showing their occurrence due to surface-area, elevation, pH and conductivity. Based on all this information crustaceans have been used as bioindicators for ecological status assessments (i.e. acidification and eutrophication) and, from 2018, they are also included in the Norwegian implementation of the Water Framework Directive (WFD), together with indicators based on benthic invertebrates.

01-O The effects of chemical warfare agent Clark I on life histories of *Daphnia magna*.

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Chemical warfare agents (CWA) dumped in aquatic reservoirs in several regions of world pose an potential environmental hazard. Leakage of CWA from eroding containers at dumping sites had been observed, and their presence in tissues of aquatic animals was confirmed. However, the ecological effects of CWA have not been studied yet. In standardized laboratory bioassays we tested if sublethal concentration of Clark I, an arsenic based CWA, may affect life histories (somatic and population growth rate, fecundity, size at maturity) and stable isotopes signatures of a keystone crustacean grazer *Daphnia magna*. We found that the life histories of daphnids reared in the presence of Clark I differed from those reared in Clark-free conditions. The finding indicates that even sublethal concentrations of Clark I can affect crustacean populations, which should be taken into accounted when assessing environmental risks of this particular CWA.

01-O Population structure of *Diaphanosoma dubium* (Branchiopoda: Ctenopoda: Sididae) along an elevation gradient in the Pearl River basin.

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Within a large river system, elevation can be one main factor affecting population structure of aquatic organisms. Ponds, lakes and reservoirs scatter within the basin, but water flow from upstream to downstream provides a strong link between these island-like habitats. Dispersal become much easy from upstream to downstream along the elevation gradient in aquatic organism. Random local colonization and local adaptation may lead to monopolization scenario, especially for zooplankton species with a large population size. In order to understand the monopolization assumption for tropical and subtropical cladoceran species, we used mitochondrial COI genes and neutral microsatellite markers to conduct a genetic analysis of 29 populations of *Diaphanosoma dubium* collected within a large elevation range from 10 m to 1976 m above the sea level in the Pearl River basin, the third largest river system in China. Our results showed that the ancient haplotypes occurred in the upstream of high elevation, and a strong gene flow was detected with COI from the upstream to the midstream and downstream. d. *dubium* had a downstream-biased dispersal in the Pearl River basin, i.e. a gene flow with water flow. Microsatellite-based DAPC analysis showed there were three populations clusters for all sampled populations, corresponding to high, middle and low land populations, and revealed there was an explicit spatial pattern of population genetics at whole watershed scale, but a random colonization pattern within a local region. Within one of the region clusters, the monopolization scenario appears to be the priority effect of random dispersal.

01-O Trade-off in *Daphnia*-microbiota in adverse conditions.

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Growth and survival defense trade-off have been investigated in prey-predator and host-parasite relationship, and recent climate change has dramatic effects on these interactions. Similarly, the host-symbiotic relation is crucial for survival but in most cases considered as synergistic and poorly understood in adverse conditions. A series of experiments were carried out to investigate how *Daphnia* symbiosis against cyanobacteria tolerance is affected by an additional stressor. *Daphnia* with specific bacterial communities were either exposed to *Microcystis* and Chlorella and or fed with pure Chlorella. Offspring produced were exposed to high amount of *Microcystis* to confirm tolerance. In addition offspring were also exposed to different concentrations of calcium, salinity, and temperature to find trade off in stressful conditions. Results showed that when tolerant offspring were exposed to additional stressor which mostly affects *Daphnia* such as calcium, it significantly reduced its growth and survival as compared to those stressor which affect both *Daphnia* and (salinity and temperature). These findings are important to understand the *Daphnia*-microbiota interactions in changing climate conditions and to better predict complex interactions in aquatic ecosystem.

01-O Effects of predation and fatty acids on diel vertical migration of zooplankton across a transparency gradient in Boreal Lake.

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It has been shown by several studies that zooplankton diel vertical migration (DVM) is mainly driven by predator avoidance and resource acquisition. Yet recent evidence suggests that ultraviolet radiation (UVR) may also be important in driving zooplankton DVM in some systems. Here we test the "transparency-regulator hypothesis'' which predicts that the relative roles of UVR and visual predation pressure will vary across a gradient of lake transparency in a non-additive manner. More precisely, the influence of UVR is expected to be a driver of DVM only in fishless clear lakes, since fish predation is expected to override its effects in all other situations. We tested this hypothesis by sampling 17 boreal lakes for vertical distribution of zooplankton at midday and midnight along independent gradients of fish predation and DOC (2 to 12 mgC/L) in Quebec (Canada). Study lakes showed different gradients of fish predation, with three of them being fishless. We used a comparative approach to examine the effects of UVR, photosynthetically active radiation (PAR), fish, temperature and food resources to calculate the amplitude of DVM between midday and midnight on different zooplankton taxa. Our first results suggest that the DVM amplitude is greater in more transparent lakes and even greater in lakes that have high predation pressure.

01-O The anti-aging effect of resveratrol and quercetin on *Daphnia carinata*.

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Daphnia are a group of small crustacean. They have numerous characteristics that make them a novel and versatile model for aging research. They have short lifespans, and tractable genetics. In this study, we use *Daphina carinata* as a test organism, to investigate the anti-aging effects of two flavonols, resveratrol and quercetin on it. The results show that different concentrations of resveratrol and quercetin had significant effects on the average life span and net reproduction rate of d. *carinata*. After 7d treatments of different concentrations of resveratrol and quercetin, the biochemical indexes were significantly different among different groups. The glucose, triglyceride and FFA level significantly decreased as the concentrations of resveratrol and quercetin increased. The results showed that both resveratrol and quercetin could increase the average lifespan of d. *carinata*, while quercetin could also increase the max lifespan of d. *carinata*.

01-O Competition of two congeneric species in *Diaphanosoma* explains their spatial ranges.

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Diaphanosoma excisum and *Diaphanosoma dubium* are common and dominant species in tropical and subtropical waters, respectively, but rarely coexist in waterbodies in the transition between tropics and subtropics. We assume the sharp niche separation between the species explain their range in spatial distribution. We did a group of life-table experiments for clones from populations of the two species to determine their thermal performance curves (TPCs). Clones of d. *excisum* had narrower TPCs and higher optimum temperatures than d. *dubium* clones, in accordance with predictions based on changes of temperature distributions with latitude. The difference between critical thermal minimum of d. *dubium* and d. *excisum* helps explain their distribution. We speculate there is a strong interspecific competition resulting in the sharp niche divergence and range delimitation. To explore their exploitative competition, we measured the population growth of the two species cultured alone or together at two temperatures and food concentrations typical in habitats where they occur. d. *excisum* has higher intrinsic population growth rates and higher peak population densities than d. *dubium* in monocultures under all combinations of food and temperature, indicating a higher carrying capacity and lower threshold

food concentration for d. *excisum.* d. *excisum* has higher peak population densities in competition cultures and excludes d. *dubium* in competition experiments. Our experiments support that interspecific competition plays a role in the range determination of the two species.

01-O Are cyanobacteria driving *Daphnia* populations and parasite dynamics? Insights from long-term investigations and sedimentary records.

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Eutrophication of freshwater lakes is known to favour cyanobacterial growth and to have negative impacts on food-webs and ecosystem functioning. Using genetic analyses on diapausing eggs from dated sediment cores from pre-alpine lakes, we have previously shown that *Daphnia galeata* invaded d. *longispina*-dominated lakes and hybridised with the native population, leading to the extinction of the natural d. *longispina* population. Previously we showed that cyanobacteria can increase *Daphnia* susceptibility to parasites. In a 12-yr monthly time-series analysis of the *Daphnia* community in Greifensee (Switzerland), we observed that cyanobacteria density correlated significantly with the epidemics of a common gut parasite of *Daphnia*, *Caullerya mesnili*, regardless of what cyanobacteria species was present or whether it was colonial or filamentous.

We now tested the hypothesis that clonal turnover should be faster during parasite epidemics than between them, by exploring field data of the *Daphnia–Caullerya* host–parasite system. The clonal make-up and turnover of the *Daphnia* host population was tracked with high temporal resolution from 1998 until 2013, using first allozyme and later microsatellite markers. Significant differences in the clonal composition between random and infected subsamples of *Daphnia* populations were detected on six of seven tested occasions, confirming genetic specificity of the host–parasite interaction in this system. We used time series analysis to compare the rates of host clonal turnover to the incidence of parasitism, and found that *Caullerya* prevalence was significantly associated with microsatellite-based clonal turnover. Other significant correlates of turnover were cyanobacterial biomass and (weakly) temperature. Overall, parasitism seems to be a strong driver of host clonal turnover.

01-O Trait heritability and evolution of *Daphnia pulex* in Japan.

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Although *Daphnia pulex* are common zooplankters zooplankton species in Japan, a recent study showed that these populationss comprised of parthenogenetic individuals and were derived from only four clones originated in North America. Among those, a clonal lineage JPN1 was estimated to have invaded in several hundred years ago. At present, the lineage includes several genotypes descended from the founding genotype that invaded into Japan. Comparison of phenotypic traits among these genotypes, therefore, provide a unique chance opportunity to examine what traits haves been genetically diverged and what types of environmental factors have importantly acted as selective agents. To better understand the reasons for invasive success of this species, we experimentally measured life history traits (e.g., maturation age and clutch size), morphological traits (e.g. apical spine length and egg size) and digestive traits (e.g. digestive enzyme activities) of five different genotypes in JPN 1, and also examined heritability of these traits with genetic distance among the genotypes. We found that most of the traits examined were significantly different among the genotypes and that broad-sense heritability was highest in digestive traits, followed by morphological and life history traits, suggesting that food condition may have been a prominent evolutionary force. In addition, although different types of traits was

often correlated with each other, relative population growth rate under experimental food conditions correlated with lipase activity alone, indicating that digestive enzyme activity can be a trait that directly affect *Daphnia* fitness. We also found that degree of phenotypic differences in any heritable traits did not relate with genetic distance estimated by whole-genome sequencing, suggesting that large phenotypic differences can be emerged by a felimited numbers of mutations regardless of number of mutations accumulated. The possibility implies that d. *pulex* have a capacity to adapt rapidly to novel environments, which enable them to expand their distribution areas.

01-O Direct and indirect effects of resource P-limitation differentially impact population growth, life history and body elemental composition of a zooplankton consumer.

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One of the central tenets of ecological stoichiometry is that consumer growth rate is strongly determined by food phosphorus (P) content. In planktonic organisms population growth rates of zooplankton have repeatedly been shown to be reduced by food P limitation. However, P-limitation may also affect other quality-related aspects of algae, such as biochemical composition or palatability. We studied the population growth, detailed life history and body elemental composition of the herbivorous rotifer, *Brachionus calyciflorus*, in response to three food qualities: high P cultured algae (C:P=112,'HP'), low P cultured algae (C:P=631, 'LP') and LP algae spiked with P just before feeding (C:P=113, 'LP+P'). LP+P algae thus combined high P content with a growth history under P-limited conditions. Total P content and the C:P ratio of rotifers in LP+P treatment equaled those in HP treatment. Rotifer population growth rates were higher in HP than in LP and intermediate in LP+P treatment. Similarly, many life history traits of animals in LP+P treatment, such as somatic growth rate, age at maturity, and egg production rate were also intermediate to those in LP and HP treatments. However, there were important deviations from this pattern: size at first reproduction and egg mortality in LP+P treatment equaled HP treatment, whereas size and development time of the first eggs equaled those of LP treatment. Our results indicate that elemental limitation cannot fully explain reduced performance of consumers fed with P-limited algae and strongly suggest that indirect, non-stoichiometric effects of P-limitation, e.g. via algal changes in biochemical composition or morphology also play a major role. Furthermore, our study highlights that such indirect effects have a differential impact on major fitness components and may as such also determine the population dynamics and demographic structure of consumer populations

01-P Spatial heterogeneity in induced defense of *Brachionus calyciflorus* within a single lake caused by a bed of foating‑leaved macrophyte *Trapa* species.

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Induced defense by the presence of predator has been widely found in various aquatic

organisms, although our understanding in the natural environments is still limited. We studied two relatively overlooked questions using *Brachionus calyciflorus*, whether induced defense is variable between microhabitats within the same lake and how multiple predator species affect induced defense in the natural environment. *B. calyciflorus* is known to elongate posterolateral spines as a defensive trait when exposed to their predator *Asplanchna*. We tested whether *B. calyciflorus* showed the different development degree of the induced defense depending on the density of its predators, *Asplanchna* and cyclopoid copepods, which differs between the microhabitats of a macrophyte bed consisting of *Trapa* species and open water without the macrophyte.

After the *Trapa* bed fully developed in summer, spatial difference occurred in both induced defense of *B. calyciflorus* and the density of its predators between the macrophyte bed and open water. *B. calyciflorus* was more abundant and had larger spines in open water than in the *Trapa* bed. *Asplanchna* was also more abundant in open water, whereas cyclopoid copepods was so in the *Trapa* bed. The statistical analysis suggested the significant effects of both the predators on the development of defensive trait, although *Asplanchna* had a positive effect while cyclopoid copepods had a negative effect. In addition, the degree of *Trapa* cover had a significant effect on the development of defensive trait and the densities of the two predators. These results suggest that the *Trapa* bed caused the spatial difference of the development degree of induced defense of *B. calyciflorus* through changing the distribution of their predators. Moreover, the induced defense of *B. calyciflorus* seems to have effectively reduced the predation risk from *Asplanchna*, whereas they appeared to have failed to avoid the predation from cyclopoid copepods.

01-P Physiological response of *Chrysosporum ovalisporum* to dissolved organic phosphorus.

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In order to investigate the mechanism of outbreak and invasion of *Chrysosporum ovalisporum*, this paper studied the physiological response of *Chrysosporum ovalisporum* to different dissolved organic phosphorus compounds. Experimental treatments consisted of the application of one of seven different forms of phosphorus (dipotassium hydrogenphosphate, sodium pyrophosphate tetrabasic decahydrate, sodium tripolyphosphate, β-glycerol phosphate, D-glucose-6-phosphate, (2-aminoethyl) phosphinic acid and glyphosate) to the P-free BG11 medium, with a control treatment (no phosphorus added) also tested .The results of the study showed that there was no significant change in the biomass of the treatment groups after three days, which showed an increasing trend from the sixth day. We observed significant increases in the biomass in two of the experimental treatments (D-glucose-6-phosphate and (2-aminoethyl) phosphinic acid) above that of the control (-P). After 15 days of culture, the maximum photosynthetic rate was highest when cells were cultured with sodium pyrophosphate tetrabasic decahydrate and D-glucose-6-phosphate, and the Fv/Fm value was 0.41. The effective photochemical quantum yield of PS Ⅱ was highest when cells were cultured with (2-aminoethyl) phosphonic acid, and the YII value reached 0.37, and lowest when cells were cultured with glyphosate, and the Fv/Fm and YII values were 0.03 and 0.16, respectively. The concentration of dissolved inorganic phosphorus of the control and glyphosate treatment did not change significantly, and the other treatment groups showed a trend of first increase and then decrease. The results of the alkaline phosphatase showed that the alkaline phosphatase activity of the different phosphorus compounds was treated in response to changes in the concentration of dissolved inorganic phosphorus. The study shows that when inorganic phosphorus is limited, *Chrysosporum ovalisporum* can use organic phosphorus to maintain its growth, but its utilization

of different phosphorus compounds is different.

01-P Study on the allelopathic effect of water extracts from *Wedelia chinensis* on the bloom forming cyanobacterium *Chrysosporum ovalisporum*.

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In order to explore the allelopathic effect of terrestrial plants on bloom forming cyanobacterial species, *Chrysosporum ovalisporum* was exposed to different concentrations water extracts of *Wedelia chinensis* during a 6 days incubation. The results showed that low concentration extracts of *W. chinensis* significantly improved the growth of *C. ovalisporum*, while the high concentrations extracts showed significantly negative effect on *C. ovalisporum*. The values of potential maximal photochemical efficiency of PSⅡ (Fv/Fm), effective photochemical quantum yield of PSⅡ (YⅡ) and chlorophyll-a (Chl-a) were significantly decreased by the extracts when its concentrations were greater than 6 $g \cdot L^{-1}$ ($P < 0.01$). Compared with the control group, the SOD and GST activity of *C. ovalisporum* in high *W. chinensis* group (8 $g \cdot L^{-1}$) were increased significantly($P < 0.05$), which indicated that *C. ovalisporum* enduring strongly environmental stress. Transmission electron microscope (TEM) pictures showed that ultra-structures of *C. ovalisporum* cells, such as thylakoid, carboxyl, gas vesicles and cell membranes were disrupted by the extracts of *W. chinensis*, consequently, resulting in the dissolution, fracture of *C. ovalisporum* filaments. In addition, the half-effect concentration (EC_{50}) of *W. chinensis* water extracts in 24 h, 48 h, 72 h and 144 h were 3.78 $g \cdot L^{-1}$, 4.47 $g \cdot L^{-1}$, 4.72 $g \cdot L^{-1}$ and 6.55 $g \cdot L^{-1}$, respectively, having been estimated by using a logical Logisitic growth model. Our study may provide newly basic data and new technical insights for the control of freshwater cyanobacterial bloom.

01-P A rough detection on extracellular metabolome of cyanobacteria *Microcystis aeruginosa*.

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Harmful algae blooms (HABs) has become a worldwide severer issue and allelopathic effects (related to allochemicals, which are also regarded as Secondary Metabolites) showed the very important reason for bloom-forming species to dominate. In this study, Liquid chromatography-tandem mass spectrometry (LC-MS/MS) was performed to roughly visualize the extracellular metabolome (metabolic profile) of bloom-forming cyanobacteria, *Microcystis aeruginosa*, in their exponential phase (6 days) conducted vacuum freeze-drying method with a concentration of 10-folds of the samples. Results showed a potent capacity of *M. aeruginosa* in secretion efficiency bioactive metabolites. We found 20 kinds of fatty acids and fatty acid derivatives, 12 steroids including plant sterols and steroids which were thought to be animal derived, 9 kinds of terpenes, 8 kinds of lactones which referred to highly antimicrobial activities and some vitamins. The principle metabolites of *M. aeruginosa* in exponential phase in consideration of the amount of each compound present as fatty acid amide, fatty acids, terpenes, steroids, and organosulfurs, in which several compounds were previously published to be toxicant

or teratogenic, e.g. beta-ionone which may involve in the biocondensation and 13-Cis-Acitretin derived from vitamin A. Most of the metabolites mentioned above occurred naturally as antibacterial, antifungal or toxicant agent. Although pretest in current study we made, these qualitatively ensured metabolites partially described how the secondary metabolite play a remarkable role in the competition processes of *M. aeruginosa* to others.

01-P *Daphnia* diversity on the Tibetan Plateau measured by DNA taxonomy.

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Daphnia on the Tibetan Plateau has been little studied, and lack of information on species diversity and biogeography. Here, we use the mitochondrial COI gene to carry out a four-year survey aimed at exploring the distribution and variation of the *Daphnia* found across the Plateau. Our results show that the species richness is higher than previously believed. The total species number increases from five to ten described and provisional species. Six of the taxonomic units recovered by DNA taxonomy agree well with morphology, but the d. *longispina* and D. *pulex* complexes split into three clades each, corresponding to D. *galeata*, D. dentifera and D. *longispina*, and D. *pulex*, D. cf. tenebrosa and D. pulicaria, respectively. The sequence divergence between congeneric species varied within a large range, from 9.25% to 30.71%. The endemic d. tibetana was the most common and widespread species. It occurred in twelve hyposaline to mesosaline lakes. The lineage of d. *longispina* was the first confirmed occurrence in West Tibet and contrasts with previous taxonomic studies.

01-P Within-lake spatio-temporal dynamics of cladoceran and diatom communities in a deep sub-tropical mountain lake (Lugu Lake) in southwest China.

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Within lake spatio-temporal variability of remains of cladocerans and diatoms were examined, using trap and surficial sediment sampling approaches in Lugu Lake, one of the deep mountain lakes in the subtropical region of southwest China, to understand the response to recent environmental change. Seasonality played a strong role in the distribution patterns of both cladocerans and diatoms, but their responses to seasonal change varied. The rich resources of food supported a cladoceran population peak during summer, while increased mixing and higher nutrient triggered diatom blooms in spring. The summer also witnessed increased grazing effects of primary consumers on diatoms when the water column was nutrient-enriched. In particular, *CerioDaphnia* intensified grazing on small diatoms (*Cyclotella ocellata*), consequently affecting community patterns during summer, while increased wind activity during spring induced turbulence, remixing, transportation and depositional processes of remains of littoral *Alona guttata* and benthic diatoms. The distribution pattern of cladocerans in surface sediments was similar to

that of diatoms. Seasonal community patterns and trophic interactions between cladocerans and diatoms in trap and surface sediments of differential depth gradients provide evidence that high-resolution sampling of multi-proxy biological remains in deep mountain lakes of southwest China can help reduce biases in paleoenvironmental reconstructions.

01-P The effect of quercetin on the lifespan, growth and seclected biochemical parameters of d. *carinata*.

Ying Yang

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Different concentrations of quercetin also had significant effects on the average life span and net reproduction rate of *D. carinata*. The average life of 1, 5 and 10 group mg/L was significant high than the control group. The RO of 1 and 5 groups was significant high than the control group. Then a stress resistance test was conducted. *D. carinata* were treated with different concentrations of quercetin for 7 d and then put into 0.25 mmol/L H_2O_2. The survival rate of all treatments was significantly higher than the control group.

01-P Co-occurrence patterns of zooplankton among reservoirs during 10 years

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We identified the co-occurrence patterns of 195 zooplankton including Copepoda, Rotifera, Cladocera in 15 reservoirs during 10 years. To identify zooplankton co-occurrence patterns among reservoirs, and the interactions among zooplanktons insects and reservoirs, we employed social network analysis methods. We used three traditional centrality measures (degree, closeness and betweenness) to determine the relative significance of each zooplankton and reservoir as a node in the network. The network pattern between nodes and edges were described on the map. Based on our network analysis, zooplankton and reservoir nodes were significantly grouped based on modularity. Widely distributed species (common species) were important to make connection in the network. Although the reservoirs were not directly connected by rivers and streams that each reservoir was isolated from other reservoir, zooplankton occurrence pattern were closely connected to reservoirs. The network analysis can be used to determine the distribution pattern and complex interaction between species and habitats.

01-P Phytoplankton community in a dry season described functional groups in small tropical eutrophic reservoirs.

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Small reservoirs are useful in coastal regions of southern China, especially in countryside in dry seasons when water is short for irrigation and animal drinking. In such reservoirs, cyanobacteria always dominated and have a potential exposure risk for human and animals. Information for phytoplankton community structure is required for management. Zhuhai is an important city providing water for Macau which faces a water shortage in dry seasons. In October 2017, we investigated 33 small reservoirs in the city, which are scatted in the coastal region. These reservoirs are characterized by very low storage capacity ($<500\times10^3 m^3$), high nitrogen and phosphorus concentrations, and high water temperature. Species from *Limnothrix*, *Merismopedia*,

Chroococcus, *Dactylococcopsis* dominated phytoplankton communities. Regression analysis results showed that total phytoplankton abundance positively correlated with total nitrogen, nitrite nitrogen, ammonia nitrogen and total phosphorus, negatively with transparency. The main functional groups of phytoplankton were composed of MP, S1, L_O, H1, N, X1, X2, J, F, P, A, D, Y, L_M. They were clustered into classes. In Class I, *Chroococcus* sp., *Merismopedia* sp., *Scenedesmus* sp. and *Dactylococcopsis* sp. were dominant, and they are S1, L_O and J of functional groups. In class II, the phytoplankton community were dominated with *Limnothrix* sp. (i.e., functional group S1). In class III, the dominant species were *Kirchneriella* sp., *Nephrocytium agardhianum*, *Staurodesmus* sp. and *Cryptomonas* sp. (i.e., functional group F, N and Y). Redundancy analysis showed that water transparency, total nitrogen, total phosphorus, ammonia nitrogen, and nitrite nitrogen were the main explainatory variables for variation of phytoplankton community described by functional groups. The present study suggested that the functional groups, S1, L_O, J, N, Y, F are able to adapt to small reservoirs with low transparency and high nutrient concentrations.

01-P Under-ice high temperature anomaly and vertical distribution of phytoplankton.

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During melting of snow and ice in spring a dilute melt water layer develops under the ice cover. Due to its lower density than elsewhere in the water column, instead of creating convection, warming by solar radiation may elevate its temperature above 4 degrees C. Until now nothing is known how phytoplankton responds to the combined temperature conductivity anomaly. We followed the development of the under-ice high temperature anomaly by continuous recording at 0.2 m depth intervals until the ice-break. We also took phytoplankton samples from the same depths.

The highest temperature level exceeding 6 degrees C was reached in 0.6-1.4 m water layer four days before the ice-break. The maximum temperature was reached at around 3 pm solar time and during night it decreased about 0.5 degrees C. At 3.5 m depth it was only 0.5 degrees C above the highest density temperature of water.

In spite of definite vertical differences in temperature and conductivity, those were not clearly reflected in the distribution of phytoplankton. Even motile species, which are capable to select their optimum location in the water column, were rather uniformly distributed at around 10 am solar time. It suggests that the uppermost water, which was more dilute in electrolytes, posed no problem, and on the other hand, phytoplankton was not favored by higher availability of light in the topmost water.

01-P Characteristics of dissolved organic matter (DOM) in eutrophic agricultural reservoir and its relation with plankton community and their biological interactions.

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Dissolved organic matter (DOM) is an organic continuum or mixture with different structures and molecular weights. DOM often reflects the status of water quality and pollution sources, and provide an important information for the reservoir managements. The two main sources of DOM in aquatic system are terrestrial input and bio-endogenous release. Terrestrial DOM transported

from the surrounding landscape to the water body, is influenced mainly by human activity, land use and sewage treatment plants. On the other hand endogenous DOM sources are created by aquatic plants', planktonic (phytoplankton and zooplankton) and microbial activity. Particularly, endogenous DOM is an important source of nutrients in the process of algal bloom outbreak. The interactions among nutrients, phytoplankton and zooplankton play an important role in the source of bio-endogenous release. Zooplankton retain nutrients in the body through grazing and assimilation, and release bioavailable nutrients into water by excretion to phytoplankton. Nutrient regeneration by zooplankton grazing has been suggested as an important process for phytoplankton succession, however, the role and related characteristics of DOM are not fully understood. In the present study, to analyse how algal decomposition and excretion of zooplankton after grazing affect the production and characteristics of DOM releases, we used the fluorescence spectroscopic techniques to measure the DOM in the target waters. Fluorescence spectroscopy can provide reliable tool to measure the structure characterization of DOM, and to monitor and understand DOM transformations in aquatic systems. The responses of DOM composition against biological activities in the plankton community, and their relationships with water quality were studied in agricultural eutrophic reservoir focusing on biological interactions in plankton community.

01-P Determination of controlling factors on temporal variation of primary productivity in Nakdong River, Korea: dual stable isotope tracer approach.

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Phytoplankton play an important role as primary producers making organic matters through photosynthesis in aquatic environments. Phytoplankton bloom is largely dependent upon physicochemical and biological conditions. Therefore, it is essential to identify the environmental factors (light, nutrients, water temperature, etc.) controlling primary productivity for conservation and restoration of aquatic ecology and environment. In order to determine a temporal variation of primary productivity and its controlling factors, we investigated the uptake rates of carbon and nitrogen by primary producers at four different sites in the Nakdong River from October to December, 2017 using a dual stable isotope tracer method ($^{13}C+^{15}NO_3$, $^{13}C+^{15}NH_4$). The primary productivities at the four sites showed temporal decreases (4~262 mg C m^{-2} d^{-1} in October, 95~543 mg C m^{-2} d^{-1} in November, 94~159 mg C m^{-2} d^{-1} in December, respectively) and revealed a positive correlation with light intensity in this study. In regards to nitrogen, the uptake rate of NO_3 (3.4~31 mg N m^{-2} d^{-1}) was substantially lower than that of NH_4 (36~795 mg N m^{-2} d^{-1}), indicating a strong preference of NH_4 as a nitrogen source for the primary producers in the Nakdong River. In addition, similar as the carbon uptake rate, the uptake rate of NH_4 consistently decreased from October to December. However, this is not resulted from the nitrogen limitation, considering high concentrations of ammonia at all the sampling sites. Instead, the temporal variation of primary productivity showed a positive correlation with light intensity. Fucoxanthin as a marker pigment for diatoms was a predominant pigment in all the study sites although a temporal increase of alloxanthin, as an indicator pigment of Cryptophytes, was observed. Based on the results from this study, the temporal decrease in primary productivity appears to be related with light intensity rather than variations of phytoplankton species and nitrogen uptake rate. However, we need to further determine how other environmental factors can affect the temporal variation of primary productivity by continuous monitoring using a stable isotope tracer method and HPLC analysis for different pigment markers.

01-P Species-specific grazing of rotifers on Cyanobacterial species using DNA technology in eutrophic reservoirs.

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Rotifers are playing an intermediate roles in connecting microbial loop and grazing food chain. However, their selective feeding behaviors and consequent its impacts on phytoplankton and bacterial communities are still insufficiently known though rotifers include various different types of grazers having different feeding structures, trophic as well as different body sizes. We applied recently developed methods using DNA technology to confirm their gut contents through laboratory experiments and field surveys in eutrophicated reservoirs. In laboratory experiments, we tested methods that can remove unnecessary extracellular DNA fragments and extracted gut contents of target rotifer species. For the field analyses, we selected reservoirs having different trophic status and environments, and collected rotifer species with measurements of water quality parameters. We tested washing method using clorox with various concentrations and treatment times for the proper pre-treatments of different rotifer species cultured in the laboratory with known food sources, and collected from the natural habitats.

01-P Response of zooplankton communities to ecological restoration in temperate eutrophic shallow lake.

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Yanglan Lake from Ezhou City, Hubei Province, is a temperate eutrophic shallow lake. The lake was restored via adding phoslock, fish removal and restoration of submerged macrophytes aim at improving water quality. We divided Yanglan Lake into repaired and unrepaired areas and monitored the water quality, zooplankton communities. The result showed that chlorophyll-a concentrations total nitrogen and total phosphorus decreased significantly and the transparency increased. The abundance of copepods increased but pollution indicator rotifer decreased after restoration.

01-P Demographic responses of cladocerans to various levels of humic acid.

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Humic substances are the natural products resulting from decomposition of organic material. In both terrestrial and aquatic ecosystems they play an important role in nutrient supply to primary producers. To increase the productivity, in most agricultural operations, humic acids are externally added. Due to run off from agricultural lands, these humic acids reach aquatic ecosystems. Among the species of zooplankton that inhabit freshwater ecosystems, cladocerans are the dominant group. They respond rapidly to changes in the aquatic environment. Though some information is available on the chemical structure and thermal stability of humic acids, information on their effects on aquatic organisms is limited. In this work we quantified the effect of humic acid on the life history variables of three common cladocerans, *CerioDaphnia dubia*, *Moina macrocopa* and *Daphnia pulex*. Cohort life table experiments were separately carried out for each of the three cladoceran species using humic acid at two concentrations 20 and 40 mg/L, besides the controls. Our data showed that gross and net reproductive rates and generation time of *C*. dubia and *D*. *pulex* were stimulated due to humic acid at both the tested concentrations. However, for M. macrocopa, the rate of population increase was significantly higher in the presence of humic acids as compared to the control. Survivorship variables of the three cladocerans were also affected but

in a species-specific manner. These results suggest that the influence of humic acids to the cladocerans is species-specific, thus affecting the zooplankton community structure in freshwater bodies.

01-P Seasonal dynamics of zooplankton communities in a large floodplain ecosystem: a test of the plankton ecology group model.

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We analysed the seasonal variation in crustacean zooplankton and a set of environmental variables covering the period winter 2009 to winter 2016 in Lake Poyang, China, to test to what extent the plankton ecology group model (PEGM) hypothesis holds for large floodplain lakes. We found that large seasonal water level fluctuations were accompanied by distinct variation in zooplankton biomass and community structure. Linear regression and Partial least squares path modelling analyses (PLS-PM) indicated that, apart from water temperature, the water level directly and indirectly affected the seasonal succession pattern of zooplankton in the lake. The main deviations of Lake Poyang from classic PEGM were: 1) higher predation pressure in autumn likely due to a shrinking water volume leaving the fish in less water, 2) stronger food limitation in winter than in spring, likely due to high concentrations of allochthonous sources in spring derived from decomposed seasonally flooded hygrophytes, 3) highest crustacean zooplankton biomass in summer when water level is high, which probably result of zooplankton`s spatial transference. In conclusion, the deviation from PEGM in the seasonal pattern of zooplankton in Lake Poyang can mainly be attributed to direct or indirect variation in physical factors, most notably in water level.

02. Macroinvertebrates and benthic communities

02-O Can habitat competition between *G. fossarum* and the non-native *Echinogammarus berilloni* influence dispersal at the invasion front in a Central European karst terrain?

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In the past years the invasive amphipod species *Echinogammarus berilloni* nearly had displaced the native species *Gammarus pulex* and *G. fossarum*, igrating upstream the river Alme catchment of the Paderborn karst plateau (NW Germany). In the present study, we examined the details of competition of the invasive amphipod against the native species for preferred habitats (leaf packs). We hypothesized that *E. berilloni* colonizes leaf packs at higher densities compared to the native species. Furthermore, that at species co-occurrence, this factor leads to a displacement of the native species in the long term. From the result of field experiments conducted with standardized alder leaf packs, competition for this preferred habitat between *E. berilloni* and *G. fossarum* was suggested. We subsequently conducted multiple flume experiments with total densities of 200 and 400 individuals, respectively, and either single or mixed populations and recorded the distribution of the specimen either inside or outside the leaf packs at the end of the experiments. From the results the hypothesis that *E. berilloni* displaces *G. fossarum*

from the preferred habitats had to be refused. Interspecific competition towards the same resource led to migration and segregation into microhabitats. Implications for the dispersal at the invasion front will be discussed.

02-O Glacial and non-glacial stream variation in benthic macroinvertebrate assemblage: pilot study in the Mount Gongga Glacier, China. *Meili Feng*

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Glaciers moderate the variation of downstream glacier-fed rivers in terms of runoff, biogeochemistry, primary production, nutrient limitation, and species diversity. Glacial melt water can induce downstream chemical and ecological changes characterized by low temperatures, high suspended sediment concentrations, and high turbidity. According to Fountain and Walder (1998), the moderating influence on runoff was found to be insignificant in basins with less than about 10% glacier coverage. Under this hypothesis, two branches of the Moxi River, located on the south-eastern margin of the Qinghai-Tibetan Plateau, were selected to investigate the biogeochemical characteristics by differing nitrogen deposition, climate, geology, or microbial processes within glacier environments. One of the tributary of Moxi River is fed by the melting water from Mount Gongga Glacier; and the other joint tributary belongs to the Dadu River basin that goes to the Min Jiang, one of the largest tributaries of the Yangtze River. We compared the benthic macroinvertebrate assemblages and their environmental relationships in these two river reaches. Species abundance distributions (SADs) of macroinvertebrates communities are compared with different levels of pollution. Results showed that nitrate in glacier meltwater and glacier-fed stream is greater than non-glacial stream. The macroinvertebrate diversity differed from the headwater of glacier-fed streams and the non-glacial streams. Community structure and spatial patterns of macroinvertebrate in the Mount Gongga Glacier area is strongly correlated with habitat diversity, nutrient loads, phytoplankton biomass, and phytoplankton community structure. The results provides valuable information for the riverine habitat conservation and biological adaptation to climate changes of increased glacial melting water environment with cold temperatures and high turbidity.

02-O Freshwater decapod crustaceans on a small, dry island. *Alasdair Dunlap-Smith*

University of New Hampshire, United State

Benthic communities in Caribbean island freshwater streams are often dominated by decapod crustaceans. Decades of research on perennial streams throughout the region, and in the El Yunque National Forest on the island of Puerto Rico in particular, provide a detailed account of their ecology and physiology. In the Virgin Islands, an archipelago of small islands on the Puerto Rican Bank, low annual rainfall and a pronounced dry season restrict ephemeral streams to small, steep catchments draining directly into the ocean. In this marginal habitat, decapod crustacean communities persist in isolated pools sustained by minimal groundwater.

In this work I report on a survey of freshwater decapod populations and available habitat on the island of St. John, USVI since 2011, spanning the 2015 Puerto Rico drought and the 2017 hurricane season. I monitored water quality and habitat partitioning within individual recurring pools, and longitudinal gradients within catchments. Interannual trends in total rainfall and rainfall intensity influence population density and species diversity. Prolonged dry-season confinement alters freshwater shrimp behavior in response to food availability and fluctuating dissolved oxygen. Varied life histories including long and short-lived species, and proximity to reliable recolonization sources identifies these freshwater decapod communities as a potential indicator connecting upslope development with economically important near-shore reefs.

02-O The fall emergence of the mayfly, *Hexagenia Limbata*, from western lake erie.

Griffiths Ronald

Oregon State University, United States

The mass emergence of *Hexagenia* mayflies during June-July from western Lake Erie has been an annual event since the early 1990s, after an absence of over 30 years. Similarly, observations of "stray" adults along the shoreline well past (August and September) this peak emergence period have commonly been reported, although their specific origin remains unknown. In October of 2016, large numbers of *Hexagenia limbata* adults were observed at Cedar Island Marina along the north shore of Lake Erie equal to about 50% of that seen the previous July, although noticeably smaller than those in July. Nymphs with black-wing pads were collected off the west side of Pelee Island and exuvae were found on the lake's surface. Size-frequency analysis indicated that eggs began hatching in early August 2016, and nymphs grew rapidly to the size that had black-wing pads in early October. Still many of the emerging adults may have been from eggs that had hatched in October 2015, a population at a very low density in the lake. No such fall emergence was noticed from Lake St. Clair.

02-O Factors determining epipelic diatom assemblage difference between artificial restored and natural urban rivers in Shanghai, China.

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Epipelic diatom plays an important role in representing ecology health as an indicator with quickly reproducing and sensitive to environmental changes. Understanding factors determining epipelic diatom assemblage composition provides information needed for enhancing effective biodiversity conservation, ecological restoration and environmental quality management. We collected the epipelic diatom of 11 artificial restored and 27 natural urban rivers in Shanghai. As a result, the hierarchical cluster analysis divided the 38 sampling sites into two large branches or five groups. Two-dimensional non-metric multidimensional scaling (N-MDS) and analysis of similarities (ANOSIM) both reflected the significant difference of inter-groups. *Cocconeis*, *Cyclotella*, *Nitzschia* and *Navicula* represented the dominating communities among five groups, which abundance accounting for 56.8%-68.1% of diatom composition. 5 groups had different dominant and indicator taxa, but the *Cyclotella meneghiniana* and *Nitzschia palea* were dominant among all groups. The striking contrast was also seen in Generic Diatom Index (GDI) and percentage of motile diatom between two-typed rivers. Classification and regression trees (CART) amplified the key environmental factors that affected the difference in epipelic diatom abundance and composition between artificial restored and natural urban rivers: dissolved organic carbon (DOC), dissolved total nitrogen (DTN) and soil salinity. This study revealed that three key factors and applied unique insights on artificial restored and natural urban rivers, which could provid the basis for further evaluating the ecological restoration.

02-O Variation of the branched sponge infauna in relation to its "state of health" in a period of ecological crisis in Lake Baikal.

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Lake Baikal is inhabited by endemic sponge family representatives – Lubomirskiidae (4 genera, 15 species) (Efremova 2001). Within the last 6 years, multiple changes have occurred in Baikal ecosystem, especially in the nearshore zone (Timoshkin et al. 2016). Disease and mass mortality of endemic Lubomirskiidae sponges is one of the most significant processes affecting the sponge fauna all over the lake. Consequently, the question arises: how is the community of invertebrates associated with Baikal sponges changing under the stressful conditions of the ecological crisis?

Sampling was carried out quarterly from December 2015 through September 2016 at two stations those are located in the Southern basin of Lake Baikal: near Berezovy Cape and Chernaya Bay. A total of 31 sponge specimens were collected by SCUBA divers from depths ranging between 5–9 m. *L. baicalensis* specimens were subdivided into 3 groups depending on type and level of their body damage: "healthy" (1), diseased (2), and dead (3).

The study revealed that infauna is normally absent inside the body of healthy *L. baicalensis* sponges. The diseased sponge bodies become accessible substrates for fauna to develop within them. The composition and abundance of infauna vary depending on the type of damage. Even untouched parts of diseased sponges harbor communities (13 ind./dm^2), that consisted of Oligochaeta, Nematoda, Harpacticoida, and Chironomidae. Along with the destruction of sponge tissue, the total number of infauna increased up to 1,300 ind./dm^2 on average, and Harpacticoida, Tardigrada, Cyclopoida, Oligochaeta were predominant. The deterioration of the Baikalian branched sponges was accompanied by the development of foulings and biofilms on their surface. In such epizoic foulings, we observed invertebrate communities with the highest density and the predominance of nematodes (18,293 ind./dm^2). Quite high density of invertebrates (4,767 ind./dm^2) was marked on the dead sponges.

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02-O Different facets of stream macroinvertebrate communities are determined by variables measured at multiple spatial levels.

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Integrating functional and phylogenetic information into studies of biodiversity patterns has become an important research program in ecology. Measuring complementary biodiversity facets (i.e. functional and phylogenetic) may be necessary for a better understanding of the patterns and dynamics of biological communities. Stream biodiversity patterns have been shown to be affected by local, catchment and climate variables; however, very few studies have concurrently studied their importance in shaping different facets of macroinvertebrate biodiversity in streams. In this study, we explored the effects of multi-level variables (i.e. local, catchment, climate and spatial variables) on species, functional and phylogenetic beta diversity of stream macroinvertebrates using a dataset based on macroinvertebrate samples collected from 105 streams sites located in

western Finland (>500 km in the north-south extension). Functional feeding groups, habit trait groups and body size measures were used as macroinvertebrate functional trait information, whereas between-species taxonomic distance was used as a proxy for macroinvertebrate phylogeny. The variation in different facets and components of beta diversity was explored using distance-based redundancy analysis (db-RDA) and associated variation partitioning approaches. Spatial variables were obtained though distance-based Moran eigenvector maps. Our results showed that local and spatial variables generally contributed to the total explained variability in all facets of beta diversity and their components, whereas catchment and climate variables were less efficient in explaining variation in the beta diversity facets at the spatial scale of this study. We conclude that analyzing different facets of beta diversity provide interesting perspectives that cannot be found if only biodiversity patterns based on species data only is considered. Analyzing biodiversity patterns based on different facets could help the improvement of biodiversity conservation efforts, and increase the understanding of current patterns and mechanisms of biodiversity.

02-O Patterns in the structure of stream macroinvertebrates community and ecosystem processes in relation with lateral and longitudinal connectivity in Arges river basin, Romania.

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Stream-riparian networks comprise strongly-linked ecosystems that underpin landscape integrity. However, they are subject to multiple human uses and pressures that affect connectivity in these networks, driving biodiversity losses, threatening ecosystem services, and causing stakeholder conflicts. A range of approaches were promoted to understand how changes in riparian habitats affect aquatic communities and ecosystem processes, but also how to deliver science-based information of real management values. Nevertheless, key drivers and their specificity at different spatial scales vary across regions and environmental context and are still poorly understood.

This paper reveals the main patterns in the structure of stream macroinvertebrates communities and ecosystem processes in forested and agricultural landscapes. A total of 30 sites, along low streams order in the Argeș River Basin, Romania were used as a case study. Redundancy analyses found significantly influential variables within each catchment, reach and habitat scale. Variance partitioning revealed their relative importance in structuring macroinvertebrates assemblages. Catchment, reach and habitat variables were almost equally influential (12% - 15%) in shaping macroinvertebrates communities, whereas variables at the catchment scale were the most influential (36%) in determining litter decomposition. Limited connectivity between streams and riparian areas restrict the abundance of EPT taxa, increase total macroinvertebrates abundance and the relative abundance of *Dipterans*, and intensify the leaf litter decomposition process. Clear patterns in the transport and sedimentation of FPOM are also revealed.

Our results appeared consistent with the concept of hierarchical functioning in which stream ecosystems are controlled by a suite of hierarchically nested bio-physical processes operating at varying space scales. They emphasise the importance of the structure and spatial configuration of

stream-riparian networks to minimize trade-offs in management while maximising multifunctionality from local to landscape scales.

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02-O Effects of light and nutrients on growth and stoichiometry of periphyton and snail grazers.

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Ecological stoichiometry posits that herbivore growth may be frequently limited by elemental nutrients rather than energy due to commonly observed large stoichiometric dissimilarity between primary consumers and their food. The light : nutrient hypothesis describes how the relative availability of light and nutrients affects food quality and food quantity, thus constrains herbivore growth by low food quality or low food quantity in aquatic ecosystems. We tested predictions of this hypothesis by examining the effects of light and nutrients on periphyton and grazer growth and stoichiometry in mesocosm experiments. Two levels of light and two levels of nutrients were provided, forming combination of four different conditions for producer and consumer in the laboratory. Periphyton had higher chlorophyll-a contents, ash-free dry mass and total C contents under high nutrient conditions, indicating relatively large quantities of periphyton available to grazers driven by a rich supply of nutrients. Periphyton elemental nutrient contents was significantly affected by nutrient conditions but not by light intensities. Periphyton C:P and N:P ratios differed between low and high nutrient conditions. Snails had higher P contents and lower C:P ratios under low light conditions, reflecting a deviation from strict homeostasis. Faster snail growth under high nutrient conditions may be due to reduced C:P imbalances between snails and periphyton, but the growth of snails was possibly more limited by N than P. Faster snail growth rates under low light conditions were related to higher consumptions rates of periphyton, and snails tend to graze more actively in the dark. Snails did not exhibit active compensatory feeding when exposed to periphyton with lower quality under low nutrient conditions. Complex interactions between environmental factors and herbivores have the potential to interfere in the process of herbivores assimilating C and nutrients, leading to observations different from the predictions of ecological theories.

02-O Effects of ecological dredging on aquatic ecology in Taihu Lake.

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Dredging was an important engineering measure to remove internal pollutant from the lakes, whose effects on aquatic ecology causing widespread concern. Parts of Taihu Lake, including Zhushan Bay, Meiliang Bay and East Taihu, were selected as the representative research area. Data on water quality, sediment chemistry, macroinvertebrate and macrophyte population before and after the implement of ecological dredging were collected through three-years' monitoring. Ecological effects of dredging projects committed by those ecological cutter-suction dredger on lake's ecosystem were investigated.

Results showed that the radius of water quality affected during the dredging processes was

about 80 m, and meanwhile total phosphorus concentration in the overlaying water increased. Total nitrogen content in the sediment decreased 40% after the complete of dredging projects, whereas no decreasing trends were detected on total phosphorus and available phosphorus in the sediment. Slight increasing trend even could be observed.

Three phylum (*Mollusca, Annelida* and *Arthropoda*), seven class (*Gastropoda*、*Lamellibranchiata*、*Oligochaeta*、*Polychaeta*、*Hirudinea*、*Insecta*、*Crustacea*), forty-four genera, species macroinvertebrate were sampled during the study period. Water quality improved from "fairly bad" to "general" based on the index of BI and BPI after the implement of dredging project in Zhushan Bay. Shannon-wiener biodiversity index, population of *Nephthys* in Meiliang Bay and *Limnodrilus Claparede* in East Taihu Lake declined remarkably three months after the complete of dredging projects, gradual recovery after six months later, and returned back to normal levels before dredging. Dredging projects implemented through various blocks in sequential phases could make each block acting as macroinvertebrate reproductive sources for others, which would speed up the recovery rate of macroinvertebrate population.

No aquatic macrophyte was sampled in the research area of Zhushan Bay and Meiliang Bay before and after the dredging projects. Floating-leaved macrophyte *Nymphoides peltatum* and *Trapa bispinosa*, submerged plant *Potamogeton malaianus*、*Vallisneria natans*、*Ceratophyllum demersum*、*Elodea canadensis*、*Hydrilla verticillata* could be sampled before the dredging projects in the research area of East Taihu Lake. While, no macrophyte could be observed even after two years.

Monomeric silicate (MSi) and total silicate (TSi) dissolved in pore water were measured using the molybdenum blue method and the inductively coupled plasma atomic emission spectroscopy (ICP-AES) technique to identify silicate species. The concentration of the dissolved PSi was calculated by determining the concentration difference between TSi and MSi. No PSi was detected in brackish lakes (Lakes Suga and Suigetsu, Japan), but both PSi and MSi were found to be dissolved in freshwater lakes (Lakes Biwa and Kawaguchi, Japan).

In anoxic sediments, silicates are preferably released from minerals rather than biogenic silica (BSi) sources such as diatoms (Lehtimäki et al. 2016). Therefore, we assume that the main source of PSi in the pore water of freshwater lakes is ferric hydroxide, which adsorbs silicates, and that major factor controlling PSi content is NaCl concentration, as this salt is the most abundant component of brackish lake water.

First, the effect of NaCl on the polymerization of silicate was examined. The NaCl concentration of a test solution (0.6 mmol/L MSi, 0 (or 0.3) mmol/L Fe^{3+} and pH 7) was adjusted to 0 or 3.5%. After standing for 1 month, the test solution was filtered to obtain filtrate 1 and precipitates. The precipitates were made to react with a Na_2S solution (pH 7) for 1 day, and filtrate 2 was subsequently obtained by filtration. The MSi and PSi concentrations were measured in their respective filtrates. PSi was not detected in filtrate 2 from the 3.5% NaCl solution but was found in filtrate 2 from the 0% NaCl solution.

To investigate the effect of NaCl on the decomposition of PSi, NaCl was added to the pore water of Lake Biwa, which was found to contain PSi. Most of the PSi was decomposed to MSi after 8 days as a result of NaCl addition.

From these results, it can be concluded that PSi is detected only in the pore water of freshwater lakes with anoxic sediment. PSi is not found in brackish lakes because its formation is inhibited by the presence of large amounts of NaCl.

02-P Applicability of stable isotopes of biofilm to monitor water environment changes in large regulated rivers.

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In river and stream ecosystems, biomonitoring indicators are the most widely used to assess water quality, particularly diatoms as good bio-indicators evaluate water quality. Recently, stable isotopes have also been successfully used to monitor water environment changes and specifically as tracers of nutrients sources. It extensively implements in vegetation, invertebrates, and fish, but a few studies mention benthic biofilm which contains abundant diatom species. Meanwhile, traditional diatom monitoring approach has some limitations. Thus, we aim to use the carbon and nitrogen stable isotope of biofilm as an additional indicator to trace the water environment changes. In the previous study, we applied it to trace water quality changes in small rivers and stream. In this study, our purpose to test the applicability of stable isotope monitoring of biofilm in large rivers. We collected the biofilm samples from four large regulated rivers in June 2017, South Korea, and analyzed their characteristics in different river environments.

02-P Changes of *Pomacea canaliculata* distribution in South Korea: current status and future.

Dae-Seong Lee, Young-Seuk Park

Kyounghee Univ., Korea

The channeled apple snail (CAS, *Pomacea canaliculata*) which is the origin of Latin America is a kind of river snail, and one of 'the World's Worst Invasive Alien Species 100' designated by the International Union for Conservation of Nature and Natural Resources (IUCN). CAS was introduced for edible purposes to South Korea in 1983. However, since 1992 it has been used for weeding in paddy fields. CAS has become popular in eco-friendly farming method for weed control, and has often found in rice paddies and open water systems all over the country. The effect of CAS on aquatic ecosystem has not been clarified yet, however damages caused by CAS has been reported recently. Therefore, CAS was designated as the second level of invasive alien species due to its potential risks by the Ministry of Environment, Korea, in 2008. In this study, we evaluated the habitat condition of CAS in South Korea on the nationwide scale based on the field surveys, literature review and Internet search. We also analyzed the expansion trend of CAS occurrence and compared the distribution patterns with social factors such as public opinion. Finally, we predicted the potential habitats of CAS in future using a species distribution model. We developed a database composed of 428 sites where CAS was observed and variables reflecting social condition. Our results showed that CAS distributed widely throughout South Korea already, and its dispersal was related to social background. In particular, we revealed that the dispersal pattern was highly related with social trends. The potential habitat area would be enlarged to all over the nation in future. Therefore CAS has high possibility to be localized in Korea as a serious pest.

02-P Response of macroinvertebrate community to the restoration in a shallow eutrophic lake.

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A restoration by means of geo-engineering, fish removal and plant transplantation was carried out in the experimental enclosure of Lake Yanglanhu, a shallow eutrophic lake in Hubei province, central China. The effect of lake restoration on macroinvertebrate community was analyzed the samples taken before and after lake restortation. The concentration of total phosphorus (TP), total nitrogen (TN), Chlorophyll *a*, suspended solids of lake water before the restoration was 0.29 mg/L, 2.48 mg/L, 30.59 μg/L, and 8.45 mg/L, respectively, and the average Secchi depth was 66 cm. After the restoration, the concentration of TP, TN, Chlorophyll *a*, suspended solids was reduced to 0.03 mg/L, 1.10 mg/L, 9.13 μg/L, and 2.02 mg/L, respectively, and the average Secchi depth increased to 183 cm. The densities of macroinvertebrates before and after the restoration were

4837.3 and 2640 ind/m^2, respectively. *Tubifex sinicus* Chen, *Limnodrilus hoffmeisteri* Claperede and *Tanypus Chinensis* Wang were the dominant species before the restoration and their densities decreased after the restoration. Howerver, molluscs densities increased after the restoration. Our results suggest that lake restoration can alter the invertebrate community significantly.

02-P Distribution and growth of *Pectinatella magnifica* (Leidy, 1851) in four large rivers of South Korea.

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Pectinatella magnifica (Leidy, 1851) is an invasive freshwater bryozoan species successfully established in the temperate climatic regions of the northern hemisphere. Although this species has been recently spreading in East Asia, existing distribution studies have been unable to reflect its growth characteristics. To address this knowledge gap, we surveyed the distribution of *P. magnifica* and its temporal growth at 52 sites on four major rivers of South Korea. We used artificial substrates to observe the initial growth of the species. We found that the average occurrence frequency of the colonies was 28.2% and *P. magnifica* was broadly distributed, occurring in mesotrophic to eutrophic conditions. The main substrates for colony attachment were the submerged dead trees and stones. However, the species did not show specific habitat preference. The colonies were detected from May to June, 2015 and were thought to have detached owing to heavy flooding during the monsoon season. Our study provides information about the environmental conditions indicating the habitat characteristics of *P. magnifica,* and is a useful guide for a more effective management of this introduced freshwater bryozoan species.

02-P Quick and Efficient method in the calculation of diatom indices for biological water quality assessment.

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This study was performed to find out the possibility of easy way to calculate diatom indices using selected benthic diatoms using relative density or indicator species analysis. Field survey was conducted from 127 sites in Seomjin and Yeongsan river on May and September 2015 and 2016. A total of 247 taxa were identified and diatom indices (TDI and DAIpo) were calculated for comparing the differences of each index value. The differences were higher in both diatom indices used only significant species in indicator species analysis (ISA) based on PO_4-P concentration against the value calculated using all species in all sites. On the other hand, the differences of diatom indices using cumulative relative density or indicator species of river systems were similar. The R^2 values of linear regression had more than 0.9 in both indices between original values and calculated values except diatom indices using indicator species of PO_4-P concentration. There were no significant differences between TDI value using all species and selective species but showed a significant difference between DAIpo value using all species and indicator species with PO_4-P concentration in Kruskal-Wallis test. The results of the significance of Spearman correlation showed similar among all metrics in both indices and the value of correlation coefficient of metrics was approximate with both indices using all species.

03.Microbial ecology and biodiversity

03-O Antarctic lake microbial ecosystems – discovery through environmental 'omics' and laboratory experimentation.

Ricardo Cavicchioli

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Low temperature is a critical environmental factor controlling the evolution and biodiversity of life on Earth. Most (~85%) of the Earth's biosphere is permanently below 5°C, dominated by ocean depths, glacier, alpine and polar regions. As the largest reservoir of ice on the planet, Antarctica exerts a great influence on the world's climate and function of the global ocean ecosystem.

In the Vestfold Hills region of Antarctica (68° 33' S, 78° 15' E), hundreds of water bodies ranging from freshwater to hypersaline (10 x marine) exist, many of which are marine-derived having been isolated from the ocean about 3-5,000 years ago. As a result they provide unique opportunities for studying the evolution of microbial populations.

In 1995 I started studying cold adapted archaea (methanogens), and in 2006 commenced an environmental genomics and proteomics program to evaluate whole lake and Southern Ocean ecosystems. One of the important things we have learned from applying shotgun metagenomics and metaproteomics is letting the data empirically describe the system, thereby discovering which microbes are present and which are key to ecosystem function in the Antarctic – discoveries which do not necessarily match preconceived expectations.

In this talk I will describe interesting microorganisms discovered in a saline meromictic lake (Ace Lake), hypersaline meromictic lake (Organic Lake) and hypersaline monomictic lakes (including Deep Lake and Rauer Island lakes). The microorganisms include bacteria (*e.g.* green sulfur bacteria), viruses (*e.g.* virophages), plasmids 'masquerading' as viruses, and archaea (*e.g.* haloarchaea, novel lineages). In describing the interesting properties of these microbes, I will cover topics in physiology, ecology, biogeography, genomic variation, microbial interactions and evolution. The talk should illustrate the synergy that can be gained by using environmental omic methods to learn about communities and generate testable hypotheses, with laboratory experimentation providing answers and new dimensions for guiding further field-based studies.

03-O Changes in bacterial community are correlated with seasonal glacial melting in a glacial-fed Tibetan lake.

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Climate change-induced glacial retreat is a global phenomenon. The effects of climate change-induced retreat on the microbial ecology in different glacial-fed aquatic systems have been illuminated in many studies, but the resolution of seasonal dynamics has been limited. Here, we studied bacterial community composition and diversity in a glacial-fed Tibetan lake to elucidate how glacial-fed aquatic ecosystems respond to the seasonal changes in glacial retreat. One of the consequences of seasonal shrinking of glaciers resulted in a remarkable seasonal fluctuation of conductivity in glacial-fed Tibetan Lake Ranwu. Our results showed that conductivity was the

major driving force in determining the bacterial community composition (30% of the variation). Bacterial alpha diversity varied among seasons and exhibited strongly negative correlations with conductivity. Proteobacteria, as the most abundant phylum in July and November, represented 50.6% and 43.0% of the total sequence, respectively. In April, bacterial communities were dominated by the Bacteroidetes (30.9%), Actinobacteria (25.8%) and Proteobacteria (25.1%). In addition, most key discriminant taxa of each season's community strongly associated with specific environmental variables, suggesting that these taxon-specific seasonal patterns may result from adaptation to specified environments. This study offered evidence for the unique seasonal dynamics pattern of bacterial communities responding to glacial retreat. Moreover, this study may provide a reference for assessing the long-term effects of glacial retreat on glacial-fed aquatic ecosystems.

03-O The utilization of alpha- and beta-mannan by marine Flavobacteriia.

Jing Chen[1], Craig Robb[2], Frank Unfried[3], Lennart Kappelmann[2], Stephanie Markert[3], Tao Song[4], Jens Harder[2], Dörte Becher[5], Ping Xie[6], Rudolf Amann[2], Jan-Hendrik Hehemann[2], Thomas Schweder[3], Hanno Teeling[2]

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About half of the global carbon dioxide fixation into organic matter is driven by microscopic algae. Microalga produced polymeric carbohydrates are food for and recycled by bacteria with polysaccharide utilization loci (PULs) which are carbohydrate-active enzymes (CAZymes) containing genetic clusters working together in recognition, depolymerizing and uptake of one type of polysaccharide. However, we rarely know the substrates of PULs present in marine bacteria. Here we investigated the proteomic and physiological response of marine *Flavobacteriia* isolated from the southern North Sea that harbor putative mannan-specific PULs. These PULs are related to genomic clusters of human gut *Bacteroides* strains, which digest α- and β-mannans from yeasts and plants, respectively. Proteomics and defined growth experiments with these types of mannans as sole carbon source confirmed that these *Flavobacteriia*' PULs indeed mediate α- and β-mannan degradation as we predicted. PUL presence was predictive of function in all tested bacteria suggesting that biochemical principles established for terrestrial microbes apply to marine bacteria even though the PULs are evolutionary distant. Moreover, our data indicate that mannan-containing polysaccharides are an important carbon resource in the ocean but the origin and abundance of which has to be revealed for a detailed understanding of the marine carbon cycle.

03-O Strategies of carbon acquisition used by chemoautotrophs in lakes.

Albin Alfreider, Monika Summerer

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Chemoautotrophic prokaryotes are mostly studied by analysing processes or molecules involved in the oxidation of reduced inorganic compounds used for the generation of energy. On the other hand, the ecological significance of diverse CO^2 fixation strategies used by chemoautotrophs in the environment is mostly unexplored. We examined the distribution and diversity of chemoautotrophs using the Calvin-Benson-Bassham (CBB) cycle, the reductive tricarboxylic acid (rTCA) cycle, and the thaumarchaeal 3-hydroxypropionate/4-hydroxybutyrate (HP/HB) pathway in stratified freshwater lakes. Several primer sets were used to sequence and

quantify genes coding for key enzymes in the three CO^2 assimilation pathways. While different forms of RubisCO, the key enzyme in the CBB pathway, were widely distributed and encompassing a wide range of potential physiologies, the rTCA cycle in *Epsilonproteobacteria* and *Chloribi* was exclusively detected in anoxic water layers. Nitrifying *Nitrospira* and *Thaumarchaeota*, using the rTCA and HP/HB cycle respectively, were important chemoautotrophs in the aphotic zone of deep lakes. Both taxa were of minor importance in surface waters and in smaller lakes characterized by an anoxic hypolimnion. Overall, this study provides a first insight on how physicochemical characteristics in lakes are associated to the distribution of chemoautotrophic prokaryotes based on an autotrophic perspective.

03-O Microbial Nitrification and Denitrification Process and the Influence Factors in Freshwater Lakes.

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Nitrogen is one of the basic nutrient element in life activities in the aquatic ecosystems, and is also a key element causing the lake eutrophication. The microbial nitrification and denitrification play an important role in nitrogen removal in lakes. It was briefly described that the microorganisms involved in the nitrification and denitrification process and its influencing factors. Investigated the heterogeneity distribution of AOA and AOB in 32 freshwater sediments from a wide range of ecologic types. The results showed that AOA and AOB were ubiquitous in all sediments and archaeal *amoA* far outnumbered bacterial *amoA* in most sediments with lower organic matters. The archaeal *amoA* gene copy numbers ranged from 6.6×10^4 per gram of dry sediment to 3.9×10^7 per gram of dry sediment, whereas the bacterial *amoA* gene copy numbers ranged from 2.6×10^5 per gram of dry sediment to 2.4×10^7 per gram of dry sediment. The abundance of AOA and AOB did not vary with the freshwater ecological type (macrophyte dominated region and algae dominated region). Based on terminal restriction fragment length polymorphism of *amoA* gene, organic matters in pore water rather than other factors could affect the AOA community structure in sediments, while the AOB were not significant different in the freshwater sediments. Phylogenetic analysis showed that all archaeal *amoA* sequences fell within either Crenarchaeotal Group (CG) I.1b or CGI.1a subgroup, and all AOB clustered with genus *Nitrosospira* or *Nitrosomonas*. The sequences affiliated with the CG I.1b (S) were all derived from sediment in the eutrophic zones, whereas in the CG I.1a (M), the sequences came from both zones. *Nitrosospira*-like sequences were ubiquitous and dominated at all sites, whereas most *Nitrosomonas Communis* sequences appeared in eutrophic zones. In eutrophic lake sediments the distribution of AOA and AOB has a significant spatial heterogeneity and organic substances have an important role in ammonia oxidizers community structure. The existence of zoobenthos in the lake has accelerated the nitration process between sediments and overlying water, and increased the abundance of ammonia oxidizing bacteria in sediments, we also found that the gut of zoobenthos can release N_2O. Therefore, the research of microbial community compositions and species diversity in aquatic ecosystems and the influence of zoobenthos on microbial community structure and function involved in N-cycling, provide a scientific basis for enriching the nitrogen cycle theory of lakes and are also the theoretical basis of eutrophication control by biological nitrogen removal.

03-O Epigenetics, is involved in the stress tolerance and adaptation in bloom-forming *Microcystis.*

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The genome of *Microcystis* is remarkable for its large number of heterogeneous restriction-modification (R-M) systems and DNA methylation modification contents as demonstrated in our previous work (doi: 10.1016/j.hal.2018.04.005). While the function of this epigenetical system is not well understood in *Microcystis*. DNA methylation modification are proved to be crucial for host specificity, antibiotic tolerance and epigenetics-driven adaptive evolution in multiple bacteria.

In this work, axenic *Microcystis aeruginosa* PCC 7806 was subjected to three types of nitrogen depletion situations, including nitrate, ammonium salt and urea, for ten days. Cells were then harvested for transcriptomic and methylomic analysis with RNA-seq and PacBio RS II sequencing, respectively. Compared to control, three nitrogen depletion treatments showed significant transcriptomic response, with more than 900 genes were significant differential expressed but the responses have not relationship with nitrogen types. Most of the methyl transferases' expression values are significant up-regulated, revealing their role in stress response in *Microcystis*. Even though detailed comparisons of genome-wide methylation percentage among four groups did not confirm significant methylome change, several motifs are found the response dramatically under nitrogen depletions. In this work, we also confirmed that a plenty of genes with different functions in *Microcystis* are regulated by DNA methylation pattern mechanism.

Our work reveals that epigenetics are contribute to the stress response of *Microcystis* and may provide new insight into the molecular mechanism for the great adaptative capacity and cosmopolitan distribution of *Microcystis* bloom as well.

03-O Recovery from near extinction is improved under resource riche conditions.

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Organisms inhabiting a fast-changing world have three options: to move, to adapt or to go extinct. However, the interplay between growth limiting factors, biodiversity, and environmental perturbation is rarely studied from an eco-evolutionary perspective. We assessed the effect of oxygen (the main limiting factor) on adaptive radiation and ecological competition of *Pseudomonas fluorescens* SBW25 under three different environmental conditions (0%, 20%, and 100% oxygen supply). In our system the only source of oxygen is at the air-liquid interface. Therefore any morphotype that evolved from the single ancestor would have to represent an adaptation towards functional traits that allows them to compete for oxygen at this surface. Initially isogenic populations were grown in a static regime for 7 days, allowing adaptive radiation to proceed. Next, a 98% non-selective mortality pulse perturbation was induced and recovery time was measured. The contrast between adaptive radiation (before) and recolonization (after perturbation) was evaluated based on the proportion of main morphological groups that evolved in the experiment. In a second experiment, we started from the most abundant of the evolved morphotypes under the three oxygen conditions. In this experiment we studied the richness of rare morphotypes radiated from the dominant single ancestor over 11 days without external perturbation. Lessons learned from both experiments were comparable. The oxygen–rich environment reduced the severity of resource competition creating room for co-existence of additional morphotypes. When the system was not restricted by its main limiting factor, increased evenness (β-), richness (γ-diversity) and reduced recovery time after a stochastic pulse perturbation (high resilience) was observed. However, when the system was deprived of oxygen the observed processes were weakened. Our study linking ecology and evolution show how the availability of resources greatly affects ecological fixation after speciation. We now aim to expand this knowledge to more complex ecosystems.

03-O Adaptive shifts of microbial communities and reduced microbial interactions along a nitrogen gradient in highly polluted running water ecosystems.

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Anthropogenic activity-mediated nutrient pollution, especially nitrogen enrichment, poses one of the major threats to river ecosystems. However, it remains unclear how and to which extent that it affects aquatic microbial communities, especially in heavily polluted rivers. In this study, we exploited variations of microbial communities and microbial interactions, and determined the key factors regulating these processes in a wastewater receiving river with a significant environmental gradient (especially nitrogen gradient). Nutrient pollution was decreasing from upstream towards downstream and separated the river into three sections with distinctive environmental variables. The dominance of Betaproteobacteria in upstream was gradually outcompeted by Gammaproteobacteria in the downstream. In addition, higher abundance of nutrient-loving groups, such as Polynucleobacter and Hydrogenophaga, was observed in upstream. Similarly, significant dissimilarity of functional group composition was observed, with highest abundance of nitrogen metabolic microorganisms in the upstream. Redundancy analysis indicated that total nitrogen (TN) was the most predictive variable for the shifts of both microbial community composition and functional groups. These results revealed the adaptive shifts of microbial communities to different levels of nutrient pollution along the river. Significant correlations were also detected between microbial interaction networks and environmental variables. The complexity of interaction networks was reduced in up- and middle stream but enhanced in downstream. With simple network structure, microbial community under heavy nutrient pollution was relatively unstable and vulnerable. In summary, the microbial community composition and functional composition were strengthened to tolerate the high-nitrogen state, which makes microbes sensitive bio-indicators to changes in environmental conditions. However, the buffering capacity of microbial communities was limited, with disrupted species-species interactions under heavy nutrient pollution. Overall, our findings provide novel insights into the relationship between aquatic microbial community and anthropogenic stresses.

03-O Disturbance-induced phytoplankton regime shifts and recovery of cyanobacteria dominance in two subtropical reservoirs.

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Many countries in the world still suffer from high toxic cyanobacterial blooms in inland waters used for human consumption. Regional climate change and human activities within watersheds exert a complex and diverse influence on aquatic ecosystem structure and function across space and time. However, the degree to which these factors may contribute to the long-term dynamics of plankton communities is still not well understood. Here, we explore the impacts of multiple disturbance events (e.g. human-resettlement, temperature change, rainfall, water level fluctuations), including six combined disturbances, on phytoplankton and cyanobacteria in two subtropical reservoirs over six years. Our data showed that combined environmental disturbances triggered two apparent and abrupt switches between cyanobacteria-dominated state and non-cyanobacterial taxa-dominated state. In late 2010, the combined effect of human-resettlement (emigration) and natural disturbances (e.g. cooling, rainfall, water level fluctuations) lead to a

60-90% decrease in cyanobacteria biomass accompanied by the disappearance of cyanobacterial blooms, in tandem with an abrupt and persistent shift in phytoplankton community. After summer 2014, however, combined weather and hydrological disturbances (e.g. rainfall, warming, water level fluctuations) occurred leading to an abrupt and marked increase of cyanobacteria biomass, associated with a return to cyanobacteria dominance. These changes in phytoplankton community were strongly related to the nutrient concentrations and water level fluctuations, as well as water temperature and rainfall. As both extreme weather events and human disturbances are predicted to become more frequent and severe during the twenty-first century, prudent sustainable management will require consideration of the background limnologic conditions and the frequency of disturbance events when assessing the potential impacts on reservoir biodiversity and ecosystem functioning and services.

03-O The composition and sources of DOM in cryoconite of the Tibetan Plateau.

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The composition of dissolved organic matter (DOM) in cryoconite is very complicated. Although there have been some researches on it, little information is known on the molecular composition and sources of DOM in cryoconite. In our study, the composition and sources of cryoconite samples from Laohugou Glacier and Tanggula Glacier were investigated using electrospray ionization (ESI) Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR-MS). The results of ESI-FT-ICR-MS showed that the total molecular population varies from 786-1019. The main types of organic carbon in cryoconite included lignin, lipids, proteins, and unsaturated hydrocarbons. Among them, lipids and proteins might originate from in situ biological activities, while lignin and unsaturated hydrocarbons might come from atmospheric aerosols and terrestrial input. The DOM come from terrestrial input were higher in cryoconite of Tanggula Glacier than Laohugou Glacier, indicating these two glaciers are effected by different atmospheric circulation.

03-O A comparison of bacterial community composition (BCC) in lakes between two polar regions.

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Polar region is an important sentinel to reflect the climate change due to weak anthropogenic perturbations. Bacterial community composition (BCC) is one of the essential factors to impact the energy flow and materials cycle in a lake ecosystem. Greenland and Tibetan Plateau, as the representative of the Artic and the third Polar, respectively, harbors plenty of lakes with different geological background and water chemistry. In this study, twenty and seventeen lakes were selected from Greenland and Tibetan plateau respectively, to explore the characteristic of BCC and to reveal the indication of bacterial response to climate changes in these polar regions. In general, the species richness (SR) of bacteria (based on OTUs) in Greenland lakes was higher than that in Tibetan lakes. The bacterial SR was much higher in sediment than that in water, no matter where the lakes located. Overall, *Betaproteobacteria* was the most dominant water taxa, followed by *Cyanobacteria* and *Actinobacteria* among selected samples both in Greenland and Tibetan lakes, whereas, *Planctomycetes* was merely abundant phyla in most of the sediment samples. *Polynucleobacter*, including lots of sub-clusters, was the most abundant genus in both regions.

The integrated analysis including all the water samples showed that Temp and nutrient level has important impact on BCC in Tibetan lakes, while dissolved oxygen (DO) condition was more important than nutrient level in Greenland lakes. In summary, the results indicated that (i) Greenland lakes possess a higher diversity of bacterial communities than Tibetan lakes; (ii) the similarity of BCC in different phase (water/sediment) is much lower than that in different regions; (iii) The response of BCC to temperature and nutrient level indicated that lakes on Tibetan Plateau might be more sensitive to the climate change and human activity.

03-O Transitions in microbial communities along a 1600 km freshwater trophic gradient.

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This study examined vertically-resolved patterns in microbial community structure across a freshwater trophic gradient extending 1600 km from the oligotrophic waters of Lake Superior to the eutrophic waters of Lake Erie, the most anthropogenically influenced of the Laurentian Great Lakes system. Planktonic bacterial communities clustered by Principal Coordinates Analysis on UniFrac distance matrices into four groups representing the epilimnion and hypolimnion of the upper Great Lakes (Lakes Superior and Huron), Lake Superior's northern bays (Nipigon and Black bays), and Lake Erie. The microbes within the upper Great Lakes hypolimnion were the most divergent of these groups with elevated abundance of *Planctomycetes* and *Chloroflexi* compared to the surface mixed layer. Statistical tests of the correlation between distance matrices identified temperature and sample depth as the most influential community structuring parameters, reflecting the strong UniFrac clustering separating mixed-layer and hypolimnetic samples. Analyzing mixed-layer samples alone showed clustering patterns were correlated with nutrient concentrations. Operational taxonomic units which were differentially distributed among these conditions were identified and often accounted for a large portion of the reads returned. While limited in coverage of temporal variability, this study contributes a detailed description of community variability that can be related to other large freshwater systems characterized by changing trophic state.

03-O Community structure of bacterial communities during cyanobacterial blooms and their dynamics during cyanobacteria decomposition.

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Worldwide cyanobacterial blooms greatly impair ecosystems in many eutrophic lakes. Both cyanobacteria and their decomposition may provide a distinct habitat for bacteria and shape microbial community structure. We investigated bacterial communities attached to cyanobacterial colonies (>120 μm, LA), free living bacteria (0.2–3 μm, FL), and small particles (3–36 μm, SA) in Lake Taihu with annual occurrence of cyanobacterial blooms and simulated cyanobacterial decomposition under different bacterial communities. The Shannon diversity index of LA was significantly lower than that of FL and SA. Cytophagia and Alphaproteobacteria were specially enriched in LA. LA provides distinct niches to bacteria, whereas the differentiation of bacterial communities in FL and SA is seasonally dependent. When cyanobacteria were subjected to decompose through incubation in 3um-filtered lake water under dark (that is, incubation with LA and FL), bacteria shifted from dominance of *Rhodospirillales* (10.9%), *Burkholderiales* (16.5%), and *Verrucomicrobiales* (14.3%) during the rapid phase (days 0–21) to dominance of

Sphingomonadales (12.8%), *Rhizobiales* (11.8%), and *Xanthomonadales* (36.5%) during the slow phase (days 21–50) of cyanobacteria decomposition. Compared to decomposition of cyanobacteria by incubation in 0.2 μm-filtered lake water (only LA) and 0.2 μm-filtered lake water with addition of sediment [LA and sediment bacteria (Sbac)], the result indicated that all the bacterial communities during rapid decomposition period were much similar to each other. However, after that, FL and LA were clustered together, whereas Sbac were much similar to FL in control. These results convinced the shaping role of cyanobacterial bloom and their decomposition on bacterial communities, further indicated cyanobacterial colonies provided special niche for the attached bacteria which have ability to decompose cyanobacteria.

03-O Community level virus diversity during a massive *Microcystis* bloom in Lake Taihu.

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Lake Tai, China, experiences annual harmful algal blooms that cause economic and environmental damages to the > 10 million people in its watershed. These blooms are commonly dominated by toxic cyanobacteria, particularly *Microcystis* spp. The drivers of bloom dynamics are not fully understood but viruses have been implicated as a potential control mechanism. However, this research has been restricted to bacteriophage infecting the dominating *Microcystis* spp. A broad diversity of viral groups has been overlooked, limiting our knowledge of the system. Here, we present an overview of seasonal, non-phage viral diversity present during the 2014 bloom. Hallmark viral genes were screened for in large metatranscriptomic libraries to identify the activity of ssRNA viruses, nucleocytoplasmic large DNA viruses (NCLDVs), and virophage. Virus activity was quantified by mapping trimmed reads back to the identified viral genes in the assembled libraries. Phylogenetic analyses revealed a broad diversity of ssRNA viruses and NCLDVs that show seasonal and spatial variability within the bloom. The ssRNA viruses appeared to be more active than the NCLDVs, with 4.2 times as many reads mapped. *Picornavirales* was the most diverse and abundant, making up 43% of total ssRNA viral reads, closely followed by Nidovirales, making up 31% of total ssRNA viral reads. The most diversity within the NCLDV's was found within a group related to *Cafeteria roenbergensis Virus* with 24 novel contigs. However, the highest expression was associated with a *Chrysochromulina ericina Virus*-like marker, representing 63% of total NCLDV activity. None of the NCLDV activity could be directly linked to any isolated virus with >85% identity, indicating a diverse community that has yet to be characterized. Virophage contigs closely related to the Dishui Lake (140 km east from Lake Tai) virophage were also identified in this system; however, they were expressed at very low abundances. This study demonstrates the presence and activity of diverse non-phage viruses in a bloom system, which encourages further investigation of the role they play in microbial community dynamics.

03-O Distribution of Virioplankton community in Typical lakes of Tibetan Plateau and its key influencing factors.

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Viruses can modulate the abundance, productivity, diversity and composition of microbial communities through infection and lysis. Meanwhile, the lytic processes of the host microbial cells infected by viruses can affect the biogeochemical cycle by releasing large amounts of cells into the lake, altering the carbon cycle and nutrient transformation and constituting the viral shunt.

We researched seven lakes (Namco, Dagzeco, Jiangcuo, Bamucuo, Gongzhucuo, Bangongcuo, Zharinanmucuo) on Tibetan Plateau to investigate the virus abundance, productivity, the decay rate of lakes over time and different distribution characteristics. The results revealed that the viral abundance was 10^6-10^7 ml^{-1} in Tibetan Plateau lakes, and it's consistent with the polar and ocean surface virus abundance. Salinity was an important factor influencing diversity and distribution of T4-like bacteriophage community in Tibetan Plateau lakes. The T4-like bacteriophage in the plateau lakes and other environment were divided obviously, which indicated that the virioplankton virus had abundant genetic diversity and significant region specificity.

Besides, based on the dynamic monitoring of the ecological characteristics of the virus in Namco lake over three days, the results showed that the abundance of virus varies in different daily cycles. Turbidity and nutrient elements were main environmental factors affecting the abundance of virus. Over the observation period, the maximum productivity of virus appeared from noon or evening to nighttime. The main environmental factors regulating viral productivity were prokaryote abundance, temperature, dissolved organic carbon and pH value. The T4-like bacteriophages of Namco lake were mainly divide into five group: Marine groups, Lake groups, Polar groups, Paddy field groups and Unique group of Namco lake. There were obvious daily changes in the community structure of T4-like bacteriophage showing the time pattern of noon, evening and morning to afternoon. The main environmental factors affecting community structure dynamics were prokaryote, chlorophyll a and turbidity.

03-O Community assembly processes underlying phytoplankton and bacterioplankton across a hydrologic change in a human-impacted river.

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Although the influence of microbial community assembly processes on aquatic ecosystem function and biodiversity is well known, the processes that govern planktonic communities in human-impacted rivers remain largely unstudied. Here, we used multivariate statistics and a null model approach to test the hypothesis that environmental conditions and obstructed dispersal opportunities, dictate a deterministic community assembly for phytoplankton and bacterioplankton across contrasting hydrographic conditions in a subtropical mid-sized river (Jiulong River, southeast China). Variation partitioning analysis showed that the explanatory power of local environmental variables was larger than that of the spatial variables for both plankton communities during the dry season. During the wet season, phytoplankton community variation was mainly explained by local environmental variables, whereas the variance in bacterioplankton was explained by both environmental and spatial predictors. The null model based on Raup-Crick coefficients for both planktonic groups suggested little evidences of the stochastic processes involving dispersal and random distribution. Our results showed that hydrological change and landscape structure act together to cause divergence in communities along the river channel, thereby dictating a deterministic assembly and that selection exceeds dispersal limitation during the dry season. Therefore, to protect the ecological integrity of human-impacted rivers, watershed managers should not only consider local environmental conditions but also dispersal routes to account for the effect of regional species pool on local communities.

03-O Bacterial communities in 600a Dagze Co sediment and Nam Co water.

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We investigated bacterial community compositions in the 37 cm Dagze Co sediment core deposited in the past 600 years. The abundance variations of dominant bacterial taxa (*Firmicutes, Proteobacteria, Actinobacteria, Bacteroidetes, Chloroflexi, Deinococcus-Thermus, Planctomycetes, Tenericutes, Verrucomicrobia, Spirochaetes*, and WS3) were statistically correlated with mean annual air temperature (MAAT), total nitrogen (N), phosphorus (P), and N:P ratio. Meanwhile, MAAT significantly affected bacterial diversity; TN, TP, and N:P ratio shaped the bacterial community composition of different year. Four taxa (primarily affiliated with *Deltaproteobacteria, Firmicutes, Planctomycetes* and *Cyanobacteria*) were identified as the potential indicator of the climate change and anthropogenic activities of the past 600 years. This study indicate that paleogenetic studies including ancient DNA analyses of non-fossilised groups expand the range of paleoclimate and paleoenvironment proxies and allow new insights into reconstruction of paleoecosystem.

We also assessed the spatio-temporal pattern of bacterial communities in Nam Co water. The bacterial communities showed pronounced vertical succession driven by chlorophyll a and photo-synthetically active radiation (PAR). Littoral bacterial assemblages in the southern and northern banks were dominated by different taxa. Bacterial abundances varied at different sites and significantly correlated with autochthonous DOC production by algae. Seasonal variation of bacterial community composition correlated with ice cover and nutrient level. Basing on these result, we understood the dynamic bacterial diversity and their relationship with environment. However, bacteria in the sediment and their indictor to the paleo-ecosystem and paleo-environment need to be further studied.

03-O *Microcystis* bloom dynamics – multiannual shift in strain domination.

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Cyanobacteria are notorious for producing water blooms and for toxin formation. Toxic cyanobacterial blooms present an ever-increasing serious threat to both the quality of drinking water and recreational uses and severely disrupt aquatic ecosystems, worldwide. In many cases, such blooms are dominated by toxic *Microcystis* sp. that produce a family of structurally similar hepatotoxins, known as microcystins (MCs). Here we present a retrospective analysis of *Microcystis* seasonal blooms from Lake Kinneret (Sea of Galilee, Israel) indicating that the population is composed of at least two strains of different geno- and chemo-types, whose relative abundance changed over decades. Based on a long-term record of biotic and abiotic parameters and laboratory experiments we propose that minor increase in water temperature may affect *Microcystis* community structure by changing the relative abundance of strains from toxic to less toxic strains.

03-P Characterization of a novel bacteriophage specific to the algicidal strain of *Exiguobacterium indicum* isolated from a plateau eutrophic lake.

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The bacterial genus *Exiguobacterium* accommodates many versatile species isolated from diverse environments. We isolated the *Exiguobacterium indicum* EI9 from plateau eutrophic lake, Dianchi Lake China, which can significantly inhibit the growth of *Microcystis aeruginosa*. No bacteriophage that infects *Exiguobacterium* has been reported, despite its potential impacts on the utilization of *Exiguobacterium*. In this study, a virulent bacteriophage, DCEIV-9, of the family *Siphoviridae* that specifically infects *E. Indicum* EI9 was isolated from Dianchi Lake water sample. Isolated phages produced tiny, round, and clear plaques with 0.5-1 mm in diameter. Electron microscopy showed that DCEIV-9 is a typical representative of the *Siphoviridae*, with an icosahedral head (56 nm in diameter) and a non-contractile tail (163 nm in length). Based on a one-step growth curve, we determined a latent period of 20 min and a burst size of 51 PFU/infected cell. At the optimal pH of 7.0, 10 % of the phages survived after a 40 min incubation at 50℃. DCEIV-9 was extremely sensitive to proteinase K, chloroform, ethanol, Trition X-100 but not sensitive to SDS. Restriction analysis indicated that DCEIV-9 is a dsDNA virus. DCEIV-9 can only infect *E. indicum*, indicates that it has a narrow host range. This work establishes a foundation for the prevention and control of bacteriophages of *Exiguobacterium* and the development of tools for the genetic manipulation, and provides a research model for the study of the interactions between algae, algicidal bacteria, and bacteriophages.

03-P Isolation and characterization of a novel phage specific to *Aeromonas rivipollensis* isolated from Dianchi Lake.

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The genus *Aeromonas* is regarded as important pathogen of fish and other cold blooded species, and also as the etiologic agent for a variety of infections in human. It has been reported that some of the species are multiple antibiotic-resistant bacterium. Phage therapy is considered to be able to reduce the impact of infection by antibiotic-resistant bacterial strains. In this study, a lytic phage infecting *Aeromonas rivipollensis* was isolated from Dianchi lake which is the largest freshwater plateau lake in China, and described the characterization and genome analysis of the phage. Morphological observation revealed that phage 2-D05 comprises a head of 43 nm in diameter and a contractile tail of about 40 nm in length. The phage could form approximate 2-3 mm clear plaque on double layer agar after 12 h incubation at 28 °C. The 2-D05 genome contains 43,233 bp with an overall GC content of 56.36%. Eighty-three putative ORFs were predicted, in which 10 encode putative structural proteins, 6 encode putative DNA replication, recombination and modification proteins, and 3 encode putative nucleotide metabolism proteins. Genome comparisons show that there're three *Aeromonas* phages related to 2-D05, with a same sequence coverage of 65% and identify of 89% respectively. The phylogenetic analysis based on portal protein indicates that 2-D05 is clustered with one of the above phages, *Aeromonas* phage vB AsaM-56. Whereas, it don't cluster with any of the known phages in the phylogenetic relationship of terminase (TerL) protein. Isolation of *Aeromonas* phage will not only contribute to the understanding of host-phage interactions, but also enrich the resource for potential phage therapy.

03-P Comparison of genomes of two *Exiguobacterium* sp. bacteriophages isolated from a plateau eutrophic lake.

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The bacterial genus *Exiguobacterium* accommodates many versatile species. No bacteriophage that infects *Exiguobacterium* has been reported, despite its potential impacts on the utilization of *Exiguobacterium*. In this study, DCEIV-9 and DCEAV-31 infect *E. indicum* EI9 and *E. acetylicum* EA31 respectively were isolated from the Dianchi Lake on Yungui Plateau (Kunming, Yunnan Province), Southwest China. These two bacteriophages cannot infect the other's host. Herein, we report the comparative genomic analysis of these two bacteriophages. The complete genome of DCEIV-9 is 51492 bp with a GC content of 45.56 %. It is highly close to those of DCEAV-31(50423 bp and 45.61%), and both have low GC content. DCEIV-9 has 92 coding genes accounted for 94.26% of the total genome length, and DCEAV-31 contains 91 coding genes for 95.39% of the total genome length. DCEIV-9 and DCEAV-31 have 23 and 22 ORF genes which can be found with similar sequences in the databases, respectively. One ORF involved in Cell wall/ membrane/ envelope biogenesis found in DCEIV-9 and DCEAV-31 was annotated using COG. Three coding genes in DCEIV-9 and DCEAV-31 were annotated using GO, and presumed to catalytic activity, biological regulation, cellular processes, metabolic processes, and biological processes. According to KEGG annotations, two coding genes of DCEIV-9 and DCEAV-31 were related to the cell cycle-Caulobacter, DNA replication, metabolic pathways, MicroRNAs in cancer, cysteine and methionine metabolism.

03-P Distribution of epipelic algae and related environmental nutrients in Lake Taihu.

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Epipelic algal biomass and composition (by HPLC pigments analysis) and related environmental nutrients were investigated in different areas of Taihu Lake (Meiliang Bay, Eastern Taihu and Gonghu Bay). Surface sediment samples were collected in April and August 2016. Average epipelic algal biomasses were 6.5, 4.9 and 4.6 μg Chl. a (g sediment)-1 in April and 3.8, 7.4 and 2.7μg Chl. a (g sediment)-1 in August for Meiliang Bay, Gonghu Bay and Eastern Taihu, respectively. The maximum biomass of epipelic algae appeared at the sampling site of G1 (9.6 μg Chl. a (g sediment)-1) in August and the minimum biomass of epipelic algae appeared at the sampling site of E4 (1.7 μg Chl. a (g sediment)-1). Pigments (fucoxanthin, zeaxanthin andchlorophyll *b*) to chlorophyll a ratios indicated that epipelic algae were primarily diatoms, secondarily cyanobacteria and lastly green algae in Lake Taihu. Epipelic algae were significantly correlated with TN in the water and total phosphorus in the sediment ($P<0.05$). In general, the epiphytic algal community was variable over time and space by utilizing pigment as an indicator. The distribution of the variation of epipelic algae was related to the heterogeneity of the environmental factors.

03-P Validation of optimal sequencing length for eDNA monitoring using fish diet based on COI barcoding region.

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Environmental DNA (eDNA) is one of the promising paths forward for the ecological monitoring. However, the usefulness of the eDNA monitoring method depends strongly on the capacity of the high-throughput sequencing platform. Identification levels (i.e. species level) and coverage of target organisms (i.e. universality) are determined and restricted by the output of the sequencing length from the high-throughput platform. To determine the optimal sequencing length for eDNA monitoring, we undertook a study to identify which of the two methodological platforms Miseq or Roche454 performed best. To find the optimal length of sequences, we divided 3 categories (658 bp [cloning: control] – 313 bp [Miseq] – 150 bp [Roche454]) based on COI barcoding region using the gut contents of 17 individuals of the generalist feeder, brown trout (Salmo trutta), from Tasmanian lakes. We obtained a copy number of sequences of 224, 918,212 and 20,519 for cloning, Miseq and Roche454, respectively and each samples showed saturated rarefaction curve. A comparison of the diversity of operational taxonomic units (OTUs) showed a significantly different number of OTUs. The number of OTUs from Miseq (n=177) was 5.4 times higher than that of the control (n=33), whereas Roche454 produced just 27 OTUs. In terms of genetic variability (haplotype), we also found different patterns. The number of haplotypes from Miseq (n=149) was 1.2 times higher than of the control (n=125), while Roche454 produced 110 haplotypes, only. We conclude that for eDNA monitoring depth of sequencing (i.e. copy number of sequences) is the most important factor, followed by sequencing length.

03-P Metagenetic analysis on symbiotic bacterial community with *Daphnia* colonizing in the hypolimnion layer of Lake Biwa.

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Daphnia spp. are important components in zooplankton communities in Lake Biwa, known as herbivorous that mainly feeding on phytoplankton in the hypolimnion waters. In Lake Biwa, however, *Daphnia* spp. recently was reported to live in the hypolimnion layer of the lake, but with few of food there because of phytoplankton was restricted in the photic zone in epilimnion layer. Recently carbon stable isotope analysis suggested the possibility that methane might be released from some specific points of the anaerobic lake bottom and then used by zooplankton and higher rank trophic level organism through methane-oxidizing bacteria (MOB). Here, we studied the microbial community structure in the whole *Daphnia* bodies, guts and feces by metagenetic analysis to reveal the possibility that the intake of a MOB by *Daphnia* and the symbiotic association between bacterial community and *Daphnia*. *Daphnia* spp. was a collected from 0-30 m and 60-90 m and each body part of individuals was separately cut and analyzed with a molecular technique. DNAs extracted from each were performed to two-step PCR targeted to V4 region of 16s rDNA in archaea and bacteria. More than 150 operational taxonomic units (OTUs) in genus level were detected from all samples, suggesting the extremely high diversity of bacterial communities related to *Daphnia* bodies, guts and feces. No archaea showed no MOB related to food web in this study. According to the phylogenetic cluster analysis in order level, bacterial

compositions in whole bodies, guts and faces were felt into different clusters, showing specific bacterial communities in each of the three compartments tested.

03-P Response of invasive fish embryos to cyanobacterial exudates.

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Cyanobacterial blooms and fish invasions have become severe problems in eutrophic lakes on a global basis, threatening many native species. Cyanobacterial exudates have been found to disturb embryonic development of a native fish species *(Sinocyclocheilus grahami*) in Lake Dianchi, China, and possibly to contribute to the disappearance and unsuccessful recovery of this endangered species. The response of invasive fish species in the same lake when exposed to cyanobacterial chemicals, however, remains largely unknown. We hypothesize that the response of the invasive fish species to these chemicals is different from the native ones. To test our hypothesis, we employed the embryos of a common invasive fish species (*Pseudorasbora parva*) in Yunnan province, China, to determine whether they exhibit tolerance to exudates of *Microcystis aeruginosa* (MaE), which is the dominant bloom-forming cyanobacterium in most eutrophic lakes. Our results demonstrated that MaE caused a reduction in fertilization (13.39%) and hatching (14.90%) rates, while malformation rate (22.48%) and mortality rate (25.20%) were slightly elevated. Adverse effects on *P. parva* caused by MaE are less serious compared with those on native *S. grahami.* Our study suggests that success of the invasive fish *P. parva* may relate to its tolerance of cyanobacterial blooms, which could, in part, facilitate successful invasion in eutrophic lakes.

05. Food webs

05-O Isoscapes reveal critical source areas sustaining floodplain river fish assemblages in northern Australia.

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Many animal populations are controlled by fluxes of energy and nutrients from outside of the habitats they occupy. However, the strength of these subsidies can vary as a consequence of fluctuations in food abundance or the ability of mobile consumers to track food resources. We used sulfur and carbon isotopes to map foraging isoscapes for aquatic consumers across two adjacent floodplain rivers in tropical northern Australia, and modelled the likelihood that a consumer derived its biomass from the location it was sampled or from elsewhere. Small bodied fish species showed a close association with local food resources, in both wet and dry seasons. However, larger mobile species appeared to be dependent on access to specific locations within inundated floodplains for much of their somatic growth. These tended to be deeper areas that retain open water and submerged macrophytes, which support high epiphyte growth. Changes to flow regimes that diminish the depth or duration of inundation of these 'hotspots' of high quality food resources, or the presence of barriers that restrict access of mobile consumers to them, are likely to significantly reduce this important floodplain subsidy to river food webs.

05-O Diet source allocation from the base of the food chain to fish organs – a compound-specific stable isotope approach.

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Dietary energy is required for growth, reproduction, and survival of organisms. Some polyunsaturated fatty acids (PUFA) are considered essential for consumers, yet in certain aquatic ecosystems their dietary provision may be too low to meet the consumers' physiological demand. In this study, we investigate how consumers along an altitudinal gradient of a subalpine stream network utilize and possibly rework lipids of allochthonous and autochthonous sources. We analyzed fatty acids and compound-specific stable isotopes (CSSI) in leaf litter, periphyton, and macroinvertebrates, as well as in fish muscle tissues and organs (liver, brain, eyes). Preliminary CSSI results show that macroinvertebrates preferably consume lipids of autochthonous sources (periphyton) and retain their long-chain PUFA eicosapentaenoic acid. Fishes, however, convert dietary PUFA to the highly unsaturated docosahexaenoic acid (DHA) in their liver and, based on lighter isotopic del^{13}C values of DHA in fish brain and eyes than in fish liver, we suggest that neural fish tissues can further synthesize DHA from precursor PUFA. These results suggest that hepatocytic DHA production may not suffice neural DHA requirements in fishes. In general, dietary lipids seem to get steadily reworked in consumers along the aquatic food web and even further in fish organs.

05-O Effects of food quality on the growth of *Daphnia similis.*

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Food quality can influence growth of zooplankton in freshwater systems. Carbon versus Phosphorus (C/P) ratio of food is closely related to food quality and it can have considerable effects on the growth of *Daphnia*. So far, researches on the effects of food C/P ratios on zooplankton were mainly conducted in laboratory, but hardly in natural water. In order to explore the effects of natural water with different food C/P ratios on the growth of *Daphnia* similis, we used water collected from 32 lakes and reservoirs to culture the D. similis. Results show that the growth rate (G) of D. similis is negatively related to the C/P ratios of food ($G = -0.0006 \times C/P + 0.2062$, $P = 0.039$), and is positively related to the phosphorus content (P) of food ($G = 0.0059 \times P + 0.1428$, $P = 0.012$). The elemental composition of food can affect the growth of D. similis. The total suspended solids (TSS) of natural water is positively related with growth rate ($G = 0.0027 \times TSS + 0.1494$, $P = 0.024$). The binary linear regression of food quality (C/P) and concentration (TSS) with growth rate is perfect ($G = 0.432 \times TSS - 0.404 \times C/P - 0.005$, $P = 0.004$), and the food quality and concentration have comprehensive effects on the growth of D. similis. The results indicate that the difference in C/P ratios of natural food can affect the growth of D. similis. The difference in food C/P ratios can affect the population density of *Daphnia*, as a consequence, it will affect the population structure of zooplankton and can alter the role of zooplankton consumer in the ecosystem.

05-O Cross-habitat linkages from aquatic insect subsidies to terrestrial consumers.

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Ecosystems are increasingly considered as highly open systems, connected by multiple cross-habitat flows of organisms, energy and nutrients that are essential for the maintenance of biodiversity, ecosystem functioning and stability at local- to landscape scales. Currently, there is growing awareness of the importance of aquatic resource transfers into terrestrial food webs via aerial movements of adult stages of aquatic insects. In eight boreal streams along a gradient of in-stream productivity (8.6 – 189 µg TP/L) we quantified the abundance of emerging insects as a measure of potential subsidy, the complexity of riparian microhabitats (e.g. soil and vegetation characteristics) and the abundance and species composition of arthropod consumers, to determine subsidy and habitat effects on riparian ground-dwelling consumers. Results showed that the distribution of arthropods was significantly correlated with aquatic subsidy abundance and microhabitat. However, the strength of the relationships varied with taxon, metric (e.g. composition, diversity) and distance from the stream edge. Distributions of carabids were most strongly related to stream subsidies, whilst staphyinids were most strongly related to microhabitat.

05-O Biomass dominance extended by true omnivore to identify keystones in real food web.

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Keystone species is essential to be identified to maintain ecosystem structure, function and stability. Biomass dominance plays an important role in identifying keystones in food web, on the other hand, true omnivore (species feeds on both plant and animal matter) also has been confirmed its importance in food web. Yet, omnivore usually has lower biomass in food web due to biomass pyramids, it is unclear how to resolve contradiction between the two points: i.e. whether it is a keystone when species was true omnivore while had low biomass. Here, in this study, we proposed keystones were defined as the high variation of food web stability caused by trophic group change. Choosing an offshore coastal wetland in Yellow River Delta (YRD) of China as a case study, a food web trophic structure model was constructed based on ^{13}C and ^{15}N determinations and Bayesian mixing model, and then food web L-V model and process-based model were established to simulate food web dynamics. We assessed food web stability indicated by diagonal interaction derived by interaction strength matrix in response to biomass change of trophic groups. Results showed that there is a significant positive correlation between biomass of trophic groups and variation of food web stability, and the true omnivores, despite their low biomass, still cause great variation in the stability of food web. The keystones in the real food web of offshore coastal wetland were sea grass, *Spartina alterniflora*, Bivalvia and Crustacean, followed by Polychaeta and Gastropoda, which, Crustacean and Polychaeta were true omnivores and had lower biomass. Overall, true omnivore could extend biomass dominance in identifying keystones in food web. These findings provide significant evidence about keystones response to food web stability, which will support food web regime shift protecting and restoration in coastal wetlands.

05-O Natural and anthropogenic drivers of freshwater food web structure: reconciling theory with empirical evidence.

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Losses in ecosystem functioning can have far-reaching consequences for biodiversity and humans alike. Although food webs are major components of ecosystem functioning, a clear

understanding of the mechanisms driving their assembly and structure is currently lacking. This is partly because of a disconnect in the focus of theoretical empirical food web studies. In this study, we aim to bring food web theory and empirical data to a closer alignment by testing the cogency of two fundamental food web theories on five high-resolution lentic food webs constructed using stomach-content and stable isotope data. Specifically, we assessed the roles of environmental filtering and biotic filtering on shaping food web structure inferred from key network topology indices (e.g., connectance, mean index of omnivory). Our data suggest that only environmental filtering shapes food web structure. Further, we found evidence to suggest that the underlying ecological mechanism is a function of bottom-up forces where high-nutrient environments favour greater food web complexity. These findings are consistent with contemporary food web theories that predict the occurrence of complex food webs in habitats where resource availability allows adaptive-prey switching. By showing congruence between theory and empirical data, our findings demonstrate that food webs can be used in predictive models; a potentially important tool for mitigating anthropogenic ecosystem function loss.

05-O Larval fish feeding ecology in mesotrophic Lake Razna, Latvia.

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The highest mortality rates during fish life cycle occur during early ontogeny when larvae switch from endogenous to exogenous feeding. This is the so called “critical period”, which highly affects recruitment to fish populations. Most studies on larval fish ecology have as of now been conducted in marine ecosystems, while only a few studies from freshwater lakes are reported. One of the few studied lakes is eutrophic Lake Võrtsjärv (Estonia), where larvae fed on ciliates exclusively. However larval fish feeding ecology in lakes with different trophic status remains an unstudied subject. Thus, we studied larval fish feeding in the relatively deep and mesotrophic Lake Razna (Latvia). Due to the patchy spatial distribution fish larvae were sampled qualitatively with a beach seine in June and July 2016. Low abundance and biomass of ciliates (1.8×10^3 n/l, 0,003 mg C/l) and zooplankton (20.3 n/l, 0.01 mg C/l) was recorded. Only *Cyprinidae* family was represented in fish samples. Gut content analysis revealed that most of the fish fed on the relatively small and slow zooplankton organisms, e.g., *Cerio Daphnia* sp. Bigger larvae started to feed on more diverse and larger zooplankton, even zoobenthos. Results from multi-response permutation procedure analysis for differences in larval fish diets didn’t show significant differences between feeding habits of fish species. Meanwhile differences in larval fish feeding habits between sampling sites and developmental stages (early larvae vs late larvae) were significant. We conclude that contrary to expectations larval fish in the mesotrophic lake Razna fed on zooplankton instead of ciliates. It is explained by the low availability of ciliates. We also found that fish size is the most important driver behind changes in their feeding habits. This points towards an existence of a “temporal bottleneck” during the early developmental stages where most of fish species` feeding niches overlap.

05-O Use of DNA barcoding to identify the prey of Eurasian otters *(Lutra lutra)* at small swimmer fish dominant sites.

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In South Korea, the Eurasian otter (*Lutra lutra*) has become remarkably re-established. In previous studies regarding otter distribution, spraints in the upper steams were at a higher density than at lower rivers. If higher density represents the density of otter populations, upper streams are not apt to have the biomass to sustain the population according to fish fauna. Most of the

undisturbed areas are located in upper streams in mountainous areas. Therefore, we hypothesized that foraging areas could be in lower river basins, and shelters could be located in upper streams. DNA barcoding could identify prey to species level. Thus, we used these methods to compare the fish fauna and diet items in 24 spraints at 16 sites in the Nakdong River basin from 4 to 6 June 2014. The fauna and diet composition were significantly different. The percentage of fish identified were dominant (52, 68.42 %), followed by frogs (20, 26.32 %), mammals (2, 2.63 %), and reptiles (2, 2.63 %). Of total study sites, *Cyprinidae* were overwhelmingly dominant (1069, 88.4 %); however, the family was much less dominant in the diet (57.69 %, 30/52). Nutria and ocean fish were identified, but study sites did not belong to the distribution of the species. Because most *Cyprinidae* are good swimming fishes, otter flexibly allowed them to feed on frogs and benthic fishes as alternative foods. Otters in upper reaches of the rivers were well adapted to low fish biomass, and otter protection should be established at a large scale according to large home ranges.

05-O Impact of seasonal water-level fluctuation on the utilization of autochthonous and allochthonous carbon and pelagic-benthic coupling in Yangtze-connected Lakes.

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Pelagic-benthic coupling proves to be one of important energy paths for the understanding of trophic dynamics in lake food webs. Due to the influence of seasonal water-level fluctuation, wetland plants immigrate and emigrate to Yangtze-connected lakes periodically and this can modify the food web structure and function, and the mechanism of carbon utilization in Yangtze-connected lakes. However, little is known about the process of wetland plants-derived carbon utilization by aquatic consumers and its nutrient cycling. Wetland plants, serve as one of important allochthonous carbon sources in Yangtze-connected lakes, can be utilized indirectly by plankton but fed directly by zoobenthos, and ultimately transfer the nutrient and energy source to higher trophic level consumers in Yangtze-connected lakes. Present study attempts to investigate the impacts of seasonal water-level fluctuation on the species composition, carbon utilization of fish and aquatic invertebrate in Lake Poyang, the largest Yangtze-connected lake in China, through the technique of stable isotopes and the analyses of TOC and C/N, and then ascertain the process and ecological mechanism of pelagic-benthic coupling induced by seasonal water-level fluctuation. Furthermore, we attempt to clarify the mechanism of carbon utilization in Yangtze-connected lakes and the process of energy cycling during different hydrological periods. Our ultimate goal is to provide theoretical guidance for the researches on the relationships between Yangtze River and Yangtze-connected lakes, and the establishment of ecological control countermeasures in Yangtze-connected lakes.

05-O Trophic position of largemouth bass estimated by nitrogen in amino acids to determine Food chain length in Freshwater ecosystem.

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Food chain length (FCL), defined as the number of trophic position of top consumer in an ecosystem, is an important characteristic to identify ecological community structure. Previous FCL studies have applied stable isotope analysis (SIA) of nitrogen in order to estimate trophic position of top predator in freshwater ecosystem. Recently compound specific isotope ratio analysis (CSIA) of nitrogen in amino acid is introduced as an alternative for SIA to estimate more accurate trophic position in aquatic ecosystem. However, this alternative method has never been applied to determine FCL in fresh water ecosystem. The present study estimate trophic position of fish caught in 4 Korean River (Han River, Yeongsan River, Geum River and Nakdong River) by nitrogen isotope ratio of amino acid (TP_{AAs}), in order to evaluate applicability of TP_{AAs} in FCL study. TP of goby minnow estimated by nitrogen isotope ratio of bulk tissue (TP_{bulk}) showed larger variation (2.0 to 4.2) than that of TP_{AAs} (2.9 to 3.4), indicating overestimation of TP_{bulk}. On the other hand, we found large ranges of TP_{AAs} in largemouth Bass (3.3 to 4.2) between 4 rivers. These different ranges in TP of largemouth bass showed great correlation with the amount of fish in their gut. The different pattern of variations in trophic position between two fish species may be due to the different feeding strategy. The food sources of benthic insectivore, goby minnow, rarely varied between different environments, while that of carnivorous largemouth bass may variable between different ecological community structures. Accordingly, our study showed applicability of TP estimation by CSIA of amino acid in predator fish (eg., largemouth bass) for FCL study.

05-P Response of river ecosystem food web to monsoon: changes in food web structure according to rainfall event focusing on fish community.

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The concentrated rainfall during summer in monsoon area is important event that can affect temporal and spatial distribution of organisms in aquatic ecosystem. It has been suggested that distribution of fish community changes dramatically after the rainy season. It indicates that ecological niche of each fish species can be affected by this event. However, the quantitative analysis of ecological niche was hard to measure until the stable isotope analysis has been applied to ecological studies. In this study, we analysed longitudinal distribution of fish community in the Nakdong River, the longest river in Korea, and we also estimated species-specific niche space of major fish by their carbon and nitrogen stable isotope ratios.

To compare pre and post monsoon, we collected fish samples in June (before rainfall) and September (after rainfall) at 9 different sites from upper to lower part of the Nakdong River. The collected fish species included alien species (*Micropterus salmoides* and *Lepomis macrochirus*) and native species (*Pseudogobio esocinus* and *Erythroculter erythropterus*). We measured carbon(13C/12C) and nitrogen(15N/14N) stable isotope ratios to compare their trophic level and theoretical area of ecological niche space. Ecological niches of *M. salmoides* and *E. erythropterus* were seriously overlapped before the rainfall with wider niche space, but separated after the rainfall. In addition, ecological niche space showed decreasing tendencies in most fish species except *E. erythropterus* after rainfall compared to dry season. Our results suggest that the inflow of organic matters and the water level changes due to rainfall can be important factors affecting the fish distribution and consequent food web structure.

05-P Fatty acid analysis reveals dietary utilization of cyanobacteria by fish in a eutrophic lake.

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Cyanobacteria has been considered as a low quality food source for aquatic animals due to toxic production and lack of essential nutrients such as 20:5n3 (EPA), 22:6n3 (DHA) and sterol. The objective of this study is to clarify whether cyanobacteria is utilized as dietary sources by fishes in a shallow eutrophic lake, Lake Hachiro, Japan where algal bloom have been observed every year. Monthly sampling was conducted to collect fish and seston from June to November, 2016 and 2017. Fatty acid compositions, stable carbon isotope ratios of a fatty acid (18:3ω3), and stable isotope ratios of bulk nitrogen were analyzed to identify their assimilated carbon sources and a trophic position. Contribution of cyanobacterial fatty acids in fish was increased after cyanobacterial bloom occurrence. In addition, stable carbon isotope ratios of 18:3ω3 in fish and seston which were mainly composed by cyanobacteria showed same value, indicating fish assimilated cyanobacterial origin dietary sources. Stable nitrogen isotope ratios indicated some fish consumed cyanobacteria directory and others utilized cyanobacterial carbon through food chain. Cyanobacterial dietary contribution for fish was much higher in 2016 than 2017, which may associated with abundance of cyanobacteria as higher amount of cyanobacteria was observed in 2016. These results imply fish utilized cyanobacteria as a dietary source in a eutrophic lake.

05-P Submerged macrophytes subsidize zooplankton: a mesocosm study using 13C stable isotope labeling.

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In the submerged macrophytes-dominated clear lakes, submerged macrophytes may control the lake water through some mechanisms, but little is known about the contribution made by submerged macrophytes to the food web. In this study, we used the 13C stable isotope labeling method to analyze the carbon subsidy of the submerged macrophytes to zooplankton. 13C-labeled submerged macrophytes were planted in the mesocosm buckets and tracked through different elements of the food web. We found clear enrichment with 13C in some zooplankton species, including *Simocephalus vetulus* and *Chydorus* (*Daphnia*), which suggests that these zooplankters can utilize submerged macrophytes carbon as a food source. Our study suggests that submerged macrophytes are important food source for zooplankton. They can build another mechanism to maintain the clear lake which dominated by submerged macrophytes.

05-P Riparian 'naturalness' influences the distribution and food sources of the Leopard cat (Prionailurus bengalensis).

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Riparian areas are at the interface of terrestrial and aquatic ecosystems, and they are important for maintaining the habitat diversity of riverine environments. Recent urbanization has rapidly modified the physical conditions of riparian habitats and has affected the distribution of riverine animals. The leopard cat (*P. bengalensis*) is the only wild Felidae in South Korea. As a top predator, leopard cats have a significant role in controlling the stability of food webs in both terrestrial and aquatic ecosystems. We compared the population density of leopard cats and their food sources in riparian areas of different levels of 'naturalness' by surveying the occurrence of

leopard cats (determined by scat occurrence) along 1 km river transects. We identified 1) distribution and habitat characteristics (landscapes, fine-scale riparian habitat conditions using Habitat Riparian Index (HRI) and Vegetation), and 2) their prey composition related with HRI values. The naturalness of a riparian habitat was evaluated using a Habitat Riparian Index (HRI). We examined 788 sites in three river basins in South Korea (Nakdong: 605 sites, Yeongsan: 92, and Seomjin: 81) from May 2016 to June 2017. Leopard cats preferred the mid to lower rivers with larger riparian areas in less urbanized areas. Additionally, the physical characteristics of a riparian habitat (i.e., levee material) was an important factor for leopard cat occurrence. The level of vegetation development and the habitat complexity of the riparian area further affected the diet composition of leopard cats; sites that were dominant with mammalian prey had higher HRI scores (HRI: 56.37 ± 2.44) than sites dominant with avian prey (HRI: 49.17 ± 3.53). Our results indicate that the physical alteration of riparian areas can affect the distribution of top predators and can modify their potential food sources.

05-P Heterotrophic microbes upgrade food value of a terrestrial carbon resource for *Daphnia magna*.

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Terrestrial carbon resources are generally regarded as inferior-quality food for zooplankton due to a lack of polyunsaturated fatty acids. However, recent stable isotope studies have identified terrestrial carbon as an important resource for zooplankton, though the mechanisms of assimilation are not well understood. Here, we consider the possibility that heterotrophic microbes can upgrade the nutritional value of terrestrial carbon and thereby support the somatic growth and reproduction of zooplankton. To test this hypothesis, a simplified experimental food chain was established. Aquatic microbes were raised under dark laboratory conditions on a terrestrial carbon source, namely decaying corn straw, and the resulting degradation products were supplied as food to *Daphnia magna*. Significant increases in microbial abundance and concomitant increases in polyunsaturated fatty acid (PUFA) were observed during the degradation of corn straw. Furthermore, experiments indicated that the somatic growth and reproduction of *Daphnia magna* was supported exclusively by the products of corn straw decay. Our results indicate a pathway for the assimilation of terrestrial carbon by zooplankton, in which heterotrophic microbes serve as trophic links.

05-P Modern chironomid larva achieves thousands of years age in a glaciated alpine lake, Tibetan Plateau.

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Natural abundance stable isotope $\delta^{13}C$ and radiocarbon $\Delta^{14}C$ analyses were applied to investigate trophic linkages between chironomid larva and their potential food sources in Lake Heihai, a glaciated oligotrophic alpine lake in the eastern Tibetan Plateau, China. We tested the hypothesis that proglacial lake food webs are supported by ancient organic carbon (OC) released from cryosphere ecosystems such as glacier and permofrost. A depleted $\Delta^{14}C$ signature of particulate and dissolved OC was found in the inflowing stream and lake, ranging from -140.2‰ to -174.8‰, corresponding to radiocarbon ages between 1150 and 1480 years. The chironomid

larva had a $\Delta^{14}C$ value of -134.8‰, reflecting that chironomid larva obtain ^{14}C depleted signatures through consumption of ancient OC and/or through assimilation of primary producers utilizing ^{14}C depleted inorganic carbon. Thus, based on a two-isotope mixing model, our results suggested that allochthonous POC and DOC were the most important carbon sources, together contributing 59.4% of the chironomid larva biomass. Recently synthesized but ^{14}C-depleted primary producers (phytoplankton and submersed plants) constituted 13.7% and 18.5% of the carbon in the diet of chironomid larva, respectively. Our findings from Lake Heihai suggest that use of ancient OC by consumers may constitute an important link between the contemporary aquatic food webs and the glaciated watershed. This link may be enforced by future climate-driven increases in glacier loss and permafrost degradation.

07. Biogeochemistry and ecosystem functioning

07-O Methane Oxidation Kinetics in Northern Freshwater Lakes.

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Aerobic oxidation converts methane (CH_4) into a relatively less potent greenhouse gas, carbon dioxide, in the presence of oxygen (O_2). Understanding the drivers of CH_4 oxidation (MOX) is therefore paramount in assessing the current and potential future emissions of natural CH_4 sources. However, regulation of MOX is a complex function of both substrates and often limited by methodological constraints involving measurements of potential rather than actual oxidation rates. While MOX activity is usually proportional to the supply or concentration of CH_4 itself, the reported effects of O_2 have been more conflicting, with maximum activity often restricted to a narrow range of oxygen concentrations. Despite the complexity involved, MOX kinetics are most often modelled as monotonic positive functions of both CH_4 and O_2 concentrations. Here, we report the results of a series of incubation experiments all using natural and unamended water samples obtained from multiple depths in northern temperate lakes that vary widely and independently in their CH_4 and O_2 concentrations. Results of our incubation experiments showed the expected positive effect of CH_4 concentration and temperature but also demonstrated the strong inhibitory effects of O_2 at high concentration. We then developed a general model describing the kinetics of MOX, simultaneously integrating the effects of CH_4 concentration, temperature as well as the non-linear effect O_2 on MOX activity. The model revealed an overall temperature dependency (activation energy = 0.49 ± 0.06 eV) much lower than reported for methanogenesis and an optimal O_2 levels around 15 μmol O_2 L^{-1} where maximum MOX activity occurs, regardless of CH_4 concentration and temperature. We further show that ignoring the inhibitory effect of O_2 can lead to significant bias in calculating the expected MOX rates in different portions of the water column.

07-O Longitudinal Discontinuities in Riverine CO_2 Dynamics in Urbanizing Asian River Systems.

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CO_2 emissions from Asian river systems represent a critical missing piece of information in the global riverine C budget. The rapid pace of urbanization across Asian river basins may affect riverine metabolic processes and CO_2 emissions, adding a large uncertainty to the global C budget estimates. Synthesis of literature data was combined with exploratory field studies in three large

Asian rivers (the Ganges, Mekong, and Yellow River) to explore how urbanization and associated water pollution affect the surface water partial pressure of CO_2 (pCO_2) via altered riverine metabolic processes along the hypothetical river continuum, which has long been used to explain longitudinal variations in "natural" riverine processes. In many Asian rivers including the three monitored rivers, pCO_2 levels were much higher along the lower reaches and tributaries downstream of large metropolitan areas, compared to the relatively low pCO_2 values observed in headwater systems. Reach-specific comparisons of dissolved organic matter (DOM) characteristics, including dissolved organic carbon (DOC) concentrations and stable isotope ratios, DOM optical intensities, and molecular signatures identified by ultrahigh resolution mass spectrometry, revealed strong influences of urban wastewater on the DOM composition in the lower reaches and tributaries. In-stream incubation experiments conducted with mainstem and polluted tributary waters in the Ganges (near Dhaka) and Mekong (along Phnom Penh) indicated stimulating effects of anthropogenic and planktonic DOM moieties on the biodegradation of DOM and CO_2 emissions. The results suggest that high levels of water pollution in rapidly urbanizing river systems can shift the balance between autotrophy and heterotrophy in eutrophic river reaches toward a C-leaking state that might deviate drastically from the gradual longitudinal pattern assumed by the traditional river continuum concept.

07-O Whole-lake metabolism in under ice conditions.

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This study will investigate under-ice whole-lake metabolism in two small waterbodies in southern Estonia, Lake Nohipalo Valgõjärv and Lake Nohipalo Mustjärv (7 ha and 22.2 ha respectively). Lake Valgõjärv represents an oligotrophic light-colored (Secchi depth 4.5 m) soft-water ($HCO^{3-} < 80$ mg L^{-1}) and shallow (max depth 12.5 m; mean 6.5 m) lake. While Mustjärv is a dystrophic dark-colored (Secchi depth 0.48 m) but also soft-water and shallow (max depth 8.9 m; mean 3.9 m) system. Lakes were equipped with Onset HOBO dissolved oxygen and water temperature/light loggers in late autumn 2015 to capture high-frequency changes of measured parameters in three depths over the winter period. Ice cover started in both lakes at the same time in December but lasted one week longer until mid-March in Nohipalo Valgõjärv. We used collected continuous data and Bayesian type depth-integrated lake metabolism model to estimate under ice net ecosystem production (NEP), community respiration (CR) and gross primary production (GPP) for studied lakes. As assumed, both lakes acted strongly as net heterotrophic (NEP < 0) waterbodies in under-ice conditions, caused by the light limitation, which turned the GPP close to zero. Despite poor light conditions, there was nevertheless a small amount of oxygen that was produced during most of the days in the upper mixed layer (epilimnion). In the dark-coloured lake there was no production in metalimnion, while in light-coloured lake a limited amount of oxygen was produced also in deeper layers.

07-O Eutrophication enhancing methane emission from lake: a case study in Lake Chaohu, China.

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Global warming and eutrophication are two world widely concerned environmental problems. Methane is the second important greenhouse gas, and lake has been proven as a quite important natural source of methane emission. More methane may emit from eutrophic lake due to the higher organic matter deposition in the lake sediment. Lake Chaohu is a shallow and eutrophic lake in eastern China (N31° 25′ ~31° 43′, E117° 16′ ~117° 05′), with an area of 770 km^2

and a mean depth of 2.7 m, and the northwest bay is the most eutrophic area of this lake. A year-round field study was carried out with 20 sites to examine methane distribution and transportation in this eutrophic lake. Samples from the different water and sediment depth was collected using headspace bottle, and methane content was measured by gas chromatography using a flame ionization detector. The potential methane production in the sediment was examined by an indoor incubation experiment. Methane flux from sediment to the overlying water, and methane emission from surface to the air were calculated. The results indicates that more methane accumulated in the northwestern bay of this lake, and higher methane emission rate was also found at this area. More methane content and the higher potential methane production was also found at northwest bay compared to the sediment from the east area of this lake. All results indicate eutrophication enhancing more methane production and emission from Lake Chaohu.

07-O Carbon cycle in a hydropower reservoir on the Yellow river, China. *Hong Yang*

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Hydropower plants use water to generate electricity, with the potential to reduce carbon emission from coal power plants. When the dams are constructed, some trees, grass and soil will be submerged and the organic matters are decomposed and mineralized to CO_2 and CH_4 and emitted to atmosphere. Despite the greenhouse gas emission from the water-air interface, large amounts of sediment deposit in the reservoir bottom and some amounts of carbon are preserved in the sediment. It is important to evaluate the carbon stock in the sediment deposits for the comprehensive understanding of carbon function of hydropower reservoirs. Xiaolangdi Reservoir, the last reservoir in the main Yellow River, was investigated in the current study. The volume of sediment deposition was up to approximately 3.07 billion m^3 in October 2014 when the mainstream delta vertex moved to 16.4 km upstream of the dam. During the operation of water impoundment and sediment detention for the Xiaolangdi Reservoir, the particle organic carbon (POC) concentrations in the reservoir water body ranged between 0.43 and 693.75 mg L^{-1}. The spatial and temporal variations of carbon in the sediment deposits and water body increase the calculation uncertainty of carbon sequestration in the reservoir bottom. The large sedimentation volume and high POC in water body indicate a potentially big carbon sink in the Xiaolangdi Reservoir and other similar hydropower reservoirs.

07-O Coupling between increased lake color and iron. *Gunnhild Riise[1], Yihua Xiao[2], Ståle Haaland[1]*

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Several boreal lakes have recently experienced increased concentrations of organic carbon and color. Even though there is a close relationship between terrestrially derived organic carbon and color, the increase in lake color is frequently more extensive than for organic carbon. Several authors claim that this "additional lake color" is partly due to increased concentrations of iron (Fe). However, the reasons for increased Fe concentrations and its coupling to color are not fully understood.

A long term survey of 24 lakes in a pristine forest area of Oslo, E-Norway (1983-2017) shows a significant increase in color, TOC, Fe, and Fe/TOC ratio with time (Mann-Kendal trend analysis). According to a color model, Fe and TOC, generally, explained 89 % of the variability in lake color, where Fe at average explained 12 % of the lake color. However, the contribution of Fe to lake color varied extensively among individual lakes, with a range from 4-40%. Neither lake color nor TOC could explain this variability, as the contribution of Fe (%) to color was not significantly related to content of TOC (range: 1-19 C mg/l) or lake color (range 2-200 Pt mg/l).

However, the individual lake's Fe/TOC ratio seemed to explain a major extent of this variability, as there was a close relationship between the individual lake's Fe/TOC ratio and the contribution of Fe (%) to color ($r^2 = 0,85$).

Terrestrially derived matter, such as organic carbon and Fe are strongly dependent on runoff, with increased concentrations during wet years. However, Fe contribution to color is less during wet compared to more dry years, indicating that the transport and/or colloidal stability of Fe in lake water differs from organic carbon. Furthermore, a larger fraction of Fe was associated with a high molecular colloidal fraction (> 10kDa) compared to TOC and color. Thus, even though organic matter has a strong affinity for Fe there is not a direct coupling between organic carbon and mineral matter such as Fe in lake water, indicating different transport pathways or existence of Fe in separate minerogenic forms (e.g. oxides) not associated with organic matter.

07-O Water Quality and Biochemistry along a 575 km stretch of the River Elbe in Germany.

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25 years ago the Elbe, a major river in Central Europe, was still considered one of the most polluted rivers in Europe. Fortunately, conditions have considerably improved over the last decades due to joint efforts of science, politics, authorities, and society. Today, the Elbe has reached bathing water quality, again. Therefore, the Federal Ministry of Education and Research of Germany (BMBF) chose the Elbe for a unique sports and science event in the frame of the 'Science Year 2016*17 — Seas and Oceans': The Elbe-Swimming Relay from 24 June till 12 July 2017. In this frame, we got the opportunity to monitor the water quality along a 575 km long stretch of the Elbe with multiple in situ and on-line sensory-devices:

(1) BIOFISH (KIT-AGW): a multi-sensor system measuring temperature, pH, turbidity, electrical conductivity, concentration of oxygen, yellow substances, chlorophyll a and cyanobacteria.

(2) PHYCOSENS (BBE Moldaenke): an optical sensor determining contents and activities different algae classes

(3) VAISALA weather transmitter (KIT-AGW): a sensor for different meteorological parameters (precipitation, air temperature, wind speed & direction, humidity and air pressure).

With these devices, a highly resolved water quality and meteorological dataset was recorded over space and time along the Elbe which was complemented by 77 selected water samples for detailed chemical analyses. Besides introducing the methods of deployment within this unique study, detailed insights into the influence of meteorology, tributaries, and algae on the water body biogeochemistry will be presented. Algae appear as the major fraction of suspended particles and are the key drivers of pH and oxygen dynamics within the system. Therefore, speciation and bioavailability of pollutant elements (particularly As and Cd) appear to be highly related to algae dynamics. Especially with regard to recent discussions about poor water quality conditions in German surface waters, this study forms a highly relevant contribution.

07-O Temporal variation in dissolved organic matter (DOM) in a shallow eutrophic lake revealed by high-frequency spectroscopic measurements.

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Dissolved organic matter (DOM) plays an important role in the biogeochemistry of lake

ecosystems. Studies measuring DOM at short intervals in lakes are still rare, thus its short-term dynamics are largely unknown. We investigated the temporal variation in DOM in a temperate large and shallow eutrophic Lake Võrtsjärv (Central Estonia) during one growing season (May-September 2016) using automatic spectrometer, and discrete water sampling along with laboratory analyses. We assessed the spectral characteristics of light absorption by DOM at a 2-hour interval using In Situ Spectral Analyzer (ISA, GO Systemelektronik GmbH) deployed in the lake. In the laboratory, absorption spectra were measured from monthly taken filtered water samples using UV-VIS spectrophotometer (UV-1700, Shimadzu); in addition, dissolved organic carbon (DOC) was measured with TOC analyzer. Absorption spectra from in situ and laboratory measurements were well correlated allowing to use the spectra measured in the laboratory as calibration reference for correcting raw spectra from automatic spectrometer for particle interferences. Different spectral parameters were used to assess the total content of DOM, the content of humic substances, and the average molecular weight and aromaticity of DOM. All parameters, i.e. the quantity and quality of DOM, varied on a large scale and were changing rapidly during growing season. High levels of DOM were mainly of allochthonous origin, strong relationship with discharge from inflowing rivers indicated the same. Low levels of DOM coincided with a greater contribution of autochthonous component. According to the discrete water sampling, average DOC concentration was 12.1 mg C L^{-1}. DOC was lowest in August and highest in May and September. Our results show that monthly taken water samples did not capture the large variation in DOM during summer months. Therefore, high-frequency measurements improve the temporal representativeness of DOM monitoring in lakes compared with traditional sampling methods.

07-O Does dissolved oxygen influence diurnal variations in N_2O emission from eutrophic shallow lakes? - A case study in Lake Wuliangsu in arid regions of China.

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The contributions of lakes to total global gaseous nitrogen emissions are remain large uncertainty. Diel dissolved oxygen (DO) variance has been documented to be a major controlling factor in the diurnal fluctuation of N_2O over the eutrophic streams and rivers, while studies that focus on the diel cycle of N_2O emissions in eutrophic shallow lakes and their links with DO concentration were still few. The purpose of this study was to determine the presence and extent of diurnal variations of N_2O in Lake Wuliangsuhai, a large shallow lake in arid regions of China, and reveal the role of DO in the production of gaseous N at the lake. We measured the diel changes in N_2O flux and associated water chemistry in the lake in August 2015, using two sampling transects that encompassed the aquatic macrophytes and unvegetated areas. Results showed that there were significant diurnal patterns in N_2O emissions and DO concentration in the aquatic macrophytes areas of the Lake Wuliangsuhai, with respective mean value of 1.99 μmol m^{-2} d^{-1} and 13.77 mg L^{-1}, while the significant diel changes of N_2O and DO were not observed in the unvegetated areas. Moreover, the maximum emission flux of N_2O (4.56±0.34 μmol m^{-2} d^{-1}) and DO concentration (18.0±0.75 mg L^{-1}) was observed from the aquatic macrophytes areas at noon, which was 72.88% and 51.04% higher than that from the unvegetated areas, respectively. High N_2O saturation was found to accompany by high NH4-N concentration at the aquatic macrophytes regions, while the N_2O saturation was observed to relate with DO level at the unvegetated areas, suggesting that N_2O production in the eutrophic shallow lake were influenced by both nitrogen and DO. We suggested that the varied N/O ratio perhaps can be used to reflect the diurnal variations of N_2O flux from eutrophic shallow lakes.

07-O Colloid-trace metal interactions in ice-covered lake Onega: Insights from organic matter colloidal pool at river - lake continuum.

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Onego Lake is the second largest freshwater lake in Europe, which is seasonally ice-covered. It is an active site for transport, transformation, and storage of considerable amounts of carbon received from the terrestrial environment. Among the different organic matter (OM) components, the highly dynamic colloidal fraction plays utmost role in the transport, speciation and bioavailability of essential and toxic elements. However, the role of colloidal organic matter (OM) pool in seasonally ice-covered lakes is still to explore. In the present work, the composition, chemical properties and molar mass distribution of the OM were characterized under ice-covered and open water condition, providing new insight in the winter carbon cycling. The possible influence of the Shuya River on the OM from Petrozavodsk Bay to the central lake of the Onego Lake, as well as, their role as trace metal carrier and bioavailability modifier were addressed for a first time in ice-covered lake. To this end the bulk properties and composition were characterized by using several natural organic matter indexes. OM composition and molecular masses were characterized by size exclusion liquid chromatography coupled with organic carbon and UV detectors. Trace metal association to OM was determined by the asymmetrical flow field-flow fractionation coupled to diode array and fluorescence detection and inductively coupled plasma mass spectrometry. The obtained results revealed that humic-like components found in the river dominated OM composition through river-bay-lake continuum. Their molecular masses distribution and the fluorescence fingerprints corrugate with fulvic type of humic like fraction, but with high aromaticity. A decrease of both molecular mass and aromaticity of OM in Petrozavodsk bay was found following the river-lake gradient in water sampled in ice-covered lake. No trends over the depth and distance from river mouth were observed in open water conditions. For trace elements such as Al, Fe, and Pb a contribution of the larger size Fe colloids and small Fe clusters was also found, following differences in iron colloids loading between March and June were shown. The consequences of the OM in trace metal bioavailability to phytoplankton were also discussed for a first time.

07-O Adsorption and polymerization of silicate and decomposition of its polymeric species in lake sediments.

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Dissolved silicate is easily adsorbed onto ferric hydroxides in suspended particulate matter and sediments at the bottom of lakes (Fischer et al. 2009). Most of these particles are semi-permanently buried in the deep sediment layer. However, in some lakes where anoxic hypolimnion occurs in the summer, the dissolved silicates seasonally increase with hydrogen sulfide, as the silicate is eluted from ferric hydroxide by its reductive dissolution (Lehtimäki et al. 2016). In this geochemical process, we found polymeric silicate (PSi) in the pore water of some lakes. Therefore, in this study, the PSi distribution in various lakes was investigated along with the formation and decomposition mechanisms of PSi in pore water.

Monomeric silicate (MSi) and total silicate (TSi) dissolved in pore water were measured using the molybdenum blue method and the inductively coupled plasma atomic emission spectroscopy (ICP-AES) technique to identify silicate species. The concentration of the dissolved PSi was calculated by determining the concentration difference between TSi and MSi. No PSi was detected in brackish lakes (Lakes Suga and Suigetsu, Japan), but both PSi and MSi were found to be dissolved in freshwater lakes (Lakes Biwa and Kawaguchi, Japan).

In anoxic sediments, silicates are preferably released from minerals rather than biogenic

silica (BSi) sources such as diatoms (Lehtimäki et al. 2016). Therefore, we assume that the main source of PSi in the pore water of freshwater lakes is ferric hydroxide, which adsorbs silicates, and that major factor controlling PSi content is NaCl concentration, as this salt is the most abundant component of brackish lake water.

First, the effect of NaCl on the polymerization of silicate was examined. The NaCl concentration of a test solution (0.6 mmol/L MSi, 0 (or 0.3) mmol/L Fe^{3+} and pH 7) was adjusted to 0 or 3.5%. After standing for 1 month, the test solution was filtered to obtain filtrate 1 and precipitates. The precipitates were made to react with a Na_2S solution (pH 7) for 1 day, and filtrate 2 was subsequently obtained by filtration. The MSi and PSi concentrations were measured in their respective filtrates. PSi was not detected in filtrate 2 from the 3.5% NaCl solution but was found in filtrate 2 from the 0% NaCl solution.

To investigate the effect of NaCl on the decomposition of PSi, NaCl was added to the pore water of Lake Biwa, which was found to contain PSi. Most of the PSi was decomposed to MSi after 8 days as a result of NaCl addition.

From these results, it can be concluded that PSi is detected only in the pore water of freshwater lakes with anoxic sediment. PSi is not found in brackish lakes because its formation is inhibited by the presence of large amounts of NaCl.

07-O Effects of pH on dissolved organic carbon decomposition in lake water.

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Although the decline of acid deposition increased the transport of dissolved organic matter (DOM) together with iron (Fe) from catchment into receiving water bodies, the pH of boreal lakes did not significantly change. We performed a series of incubation experiments (up to 647 days) to study the role of pH and Fe in the decomposition of dissolved organic carbon (DOC) of lake water. Our results showed that, both microbial and photochemical decompositions benefit from low pH (4), comparing to the ambient pH (5 and 6). When heterotrophic nanoflagellate (HNF) is present in the system, the microbial decomposition of DOC significantly increased (up to 60.1% of DOC was mineralized to CO_2), suggesting microbial decomposition of DOC is favored by the regeneration of nutrients upon grazing by HNF. We described the loss of bulk DOC with a reactivity continuum (RC) model. The RC model showed the first-order decay coefficient (k) was higher in treatment of pH 4 comparing to the treatments of pH 5 and 6 in all experiments, indicating a higher decay rate of DOC in acidic condition. The introduction of Fe to lake water acidified to pH 4 increased microbial density suggesting that Fe additionally stimulated microbial growth on DOC in acidic lake water. Our results indicate that an increase in pH after the decline of acid deposition can decrease the biological and photochemical decompositions of DOC. However, the increasing input of Fe to aquatic systems may counteract this reduction to some extent.

07-O The biodiversity-ecosystem functioning relationship in Southeast Asian fresh waters: evidence and mechanisms.

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Biodiversity has been found to be a key determinant of ecosystem functioning—pools and fluxes of biogeochemical resources mediated by the biological activities of organisms. Studies on biodiversity-ecosystem functioning (B-EF) reveal a non-linear, positive and saturating relationship.

In diverse communities, this relation is thought to be driven by niche partitioning between species ("complementarity effect"), or alternatively by the presence of species that exert strong influences on ecosystem processes ("species identity effect"). The overwhelming majority of existing B-EF studies, however, focus on terrestrial vascular plants within controlled experimental settings, while freshwater ecosystems, despite their disproportionately high biodiversity and threatened status, are relatively less well-studied. Here we aimed to characterise the B-EF relationship and elucidate the underlying mechanisms in the inland waters of Southeast Asia, a major centre of freshwater fish diversity. We examined two measures of fish-mediated ecosystem functioning—nutrient cycling and trophic energy transfers—using nutrient analysis and compound-specific isotope analysis of amino acids, respectively. Preliminary investigations revealed a positive B-EF relationship along diversity gradients within river drainage basins in the region.
We then applied probabilistic simulations to examine B-EF mechanisms in Southeast Asian freshwater fish, uncovering the dual influences of complementarity and species identity effects.

07-O Understanding nitrogen biogeochemistry in coastal urbanized rivers in Southeast China.

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The coastal areas in China have been rapidly urbanized in recent years. However, the impact of urbanization on river biogeochemistry are rarely investigated. Here we selected five lower reaches passing through urban area in Southeast China and measured nitrogen (N) species at two contrastive sites (upstream vs. downriver) during baseflow period. We observed an addition of ammonium but decline of nitrate with overall increase of dissolved inorganic N (DIN) from upstream to downriver. The increase in ammonium fraction (NH^4-N/DIN) by 1-17% suggests that a large amount of sewage and urban runoff discharge into river. An increase of dissolved N_2O and N_2 (end product of denitrification), together with the decreased nitrate, showing a marked N removal although it cannot compensate the ammonium addition. Ammonia oxidizing bacteria (AOB) dominate the nitrifier and the amoA gene abundance ($2.24\times10^2 \sim 6.12\times10^4$ copies L^{-1}) in downriver site was less than upstream site, while the nosZ gene abundance (1.99×10^4~4.39×10^5 copies L^{-1}) of denitrifier exhibited an opposite pattern. Current results indicate that urbanization might weaken nitrification and enhance denitrification and ultimately change nutrient stoichiometry and flux to coastal water. These findings provide an important implication for coastal ecology.

07-O Regional patterns of carbon and nitrogen stable isotopes and elemental composition of lake primary producers and zooplankton in Yunnan.

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The application of stable isotope methods can provide an important insight in uncovering the ecosystem structure and functioning, through revealing the trophic structure of lake food webs and the trophic pathways of biogeochemical cycling. We present a spatial survey of ten lakes in eastern Yunnan through analyzing the carbon and nitrogen stable isotopes and elemental composition for aquatic plants, phytoplankton and zooplankton, respectively. Among the four lake organisms, floating plants are characterized by the most negative signal of $\delta^{13}C$, with a mean value

(±1SD) of -28.99±0.86‰. While phytoplankton (-21.88±2.97‰) and zooplankton (-20.85±2.70‰) are characterized by similar carbon isotope values, the submerged plant has a larger variation with more positive $\delta^{13}C$ value (-12.04±4.57‰). This indicates that the difference in carbon sources absorbed or utilized and the transfer pathways has caused the deviation in $\delta^{13}C$ composition among these four organisms. In terms of stable nitrogen isotopic signal, primary producers, including submerged plants (5.43±5.84‰), floating plants (5.58±7.38‰) and phytoplankton (7.26±3.83‰), show significantly similar $\delta^{15}N$ values. While the $\delta^{15}N$ value of zooplankton (11.02±3.18‰) is significantly higher with an enrichment factor by 3.46‰, indicating the effect of nitrogen isotope fractionation across trophic levels in our lakes. Furthermore, the $\delta^{13}C$ signals of these lake organisms are also affected water temperature, water depth and lake productivity. The variation in $\delta^{15}N$ signal is affected by lake eutrophication, which leads to a gradual enrichment of $\delta^{15}N$. In addition, the carbon and nitrogen contents of aquatic organisms from Yunnan lakes are higher than those in lakes from regions such as the middle and lower reaches of the Yangtze River. There also existed a threshold C/N ratio of primary producers and primary consumers in defining the autochtonous and allothonous sources of organic matters. Thus, this spatial survey provided important data for understanding the food web composition and biochemical cycling for plateau lakes in Southwest China.

07-P Fate of cyanobacterial toxins (Microcystins) on environmental multi-media samples in Geum River Estuary, Korea.

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Microcystins (MCs) cause toxicity (e.g., hepatotoxicity) and bioaccumulation in aquatic organisms and have been found in great concentrations in freshwater environments along with cyanobacterial blooms in recent decades. Although most studies of MCs dynamics in freshwater ecosystems have been focused, fate of MCs entering the coastal environments through rivers is largely unknown. The objectives of this study were: i) to investigate load of MCs via dike of Geum River; ii) to determine multimedia fate of MCs in estuary; and iii) to elucidate bioaccumulation characteristics of MCs. Surface water, suspended particles, and sediments were collected from 7 stations (inside and outside of sea dike) in June and July 2017. Biological samples including fishes, bivalves, gastropod, crab, and polychaete were collected from the estuarine areas. Concentrations of MCs (MC-LR, -RR, and -YR) were measured in discharged water and marine multimedia samples using HPLC-MS/MS. In order to determine trophic position and carbon source of organisms, C and N stable isotope analyses were conducted using EA-IRMS. Approximately 4,300 kg of MCs was discharged to the Geum River Estuary during the period from July to August. From inner to outer estuary in June, concentrations of dissolved and particulate MCs gradually decreased from 133.6 ng L^{-1} to <DL and from 6.4 ng L^{-1} to <DL, respectively. On the other hand, dissolved MCs concentrations increased from 18.7 to 49.5 ng L^{-1} after freshwater discharge. Meanwhile, concentrations of MCs in marine organisms varied among species, ranging from 0.04 to 0.87 μg g^{-1} dw. Concentrations of MCs in biota were negatively correlated with trophic positions, indicating that MCs did not seem to biomagnify in marine food web. Bioaccumulation factor of MCs showed a significant positive correlation with $\delta^{13}C$ values, which seems to be associated with carbon sources of organisms.

07-P Biogeochemistry of foam substances from the Chikugo River system in the Hita City area, Japan.

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Foam substances are often found in aquatic environments in the world, and destroy scenic view in the resort area. Here we studied stereoscopic microscope observation and biomarkers of foam substances from the Chikugo River system in the Hita City area, especially focused on the Hita reservoir area, Japan in order to clarify their biogeochemical characteristics, source organisms and formation processes. Foam samples were taken in 2016 and 2017. Lipid biomarkers were analysed by the methods of Matsumoto *et al*. (1979, 2003). Chlorophylls and carotenoids were determined by the method of Tani *et al*. (2009).

Stereoscopic microscope observation of foam substances showed frequently the occurrence of amorphous organic matter and chrysalis cast of Chironomidae. Biogeochemical features of hydrocarbons, fatty acids and sterols strongly suggest that these biomarkers originate from microalgae with the influence of insects of Chironomidae. Major carotenoids of fucoxanthin, 19'-hexanoyloxyfucoxanthin, diadinoxanthin in foam substances are mainly originate from diatoms. The occurrence of unresolved complex mixture of hydrocarbons (UCMH) and thermally epimerized triterpanes and steranes strongly imply the influence of petroleum products pollution. They contribute probably on the formation and stability of foam substances.

The concentrations of total carotenoids and chlorophylls in surface waters (less than 5 mm in depth) in the Hita reservoir area were 43 and 40 times higher than those of bulk river waters, respectively. These results reveal that the formation of neuston community in this area. Neuston community is surface microfilms (<20 μm) composed of various organic matter (carbohydrate and lipids etc.) and microorganisms (bacteria, microalgae etc., Sigee, 2004). Stirring of the water surface by strong wind, surge and ripple forms easily foam substances. Foam substances quickly accumulate on the upper side of Yakatabune during overnight in this area.

A part of this work was done by a commissioned project of Oita Prefectural Government.

07-P Determination of trace methylphosphonate in freshwater by ion chromatography.

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Recently methylphosphonate (MPn) is payed an attention with other phosphonates as P-resource for aquatic organisms in natural waters. In Lake Saiko (Yamanashi, Japan), subsurface maximum layer of methane concentration is observed, and this layer is formed by hydrolysis of MPn by bacteria. Vertical distribution of cell densities of *Synecococcus* and other cyanobacterium was similar to that of methane concentration. Moreover, methane was produced by incubation of hybridized bacteria sampled in Lake Saiko with MPn. Although this process might be usual in P-limited lake waters, there was no data of MPn concentration in natural water samples. Thus, new analytical method for the determination of MPn in natural was developed based on ion chromatography. Analytical method of MPn was based on that for the determination of trace orthophosphate in natural waters. High capacity column and high injection volume enabled trace analysis of MPn in waters of Lake Biwa (Shiga, Japan) and its surroundings. To check the existence of MPn, standard MPn was spiked in natural samples, and chromatogram of spiked sample and that of unspiked sample were compared. In the use of eluent condition recommended by the manufacturer was not suitable for the separation of MPn from major anions (chloride, nitrate, and sulfate) in natural waters. As the peak area linearly increased with the increase in sample injection volume up to 5 mL, this volume was applied for the analysis of natural samples. Peak area showed linear increase up to 10 nmol/L, and the detection limit was 5 pmol/L (S/N=3).

MPn was detected clearly in the samples from anoxic spring water and river that was close to the spring water, with the concentration of 2-3 nmol/L. From other samples, MPn was not detected. MPn might be supplied from spring waters that has passed through anoxic environments.

07-P Changes in precipitation pattern alter inter-annual the carbon fluxes in subtropical mountain lakes with contrasting trophic status.

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Lentic freshwater ecosystems are important components of global carbon cycling, but their individual contribution varies along gradients of dissolved organic matter and productivity. We studied two subtropical lakes that differed substantially in color and trophic status to investigate how variation in annual precipitation patterns would shape inter-annual variation in ecosystem carbon fluxes (GPP, R and CO_2 flux).

Subtropical lakes are considered vulnerable to meteorological changes because they are typically relatively small, shallow, and regularly experience intense monsoons and typhoons. nstrumented buoys were deployed to record time series of free-water dissolved oxygen, colored dissolved organic matter (CDOM), chlorophyll a, water temperature profiles, and meteorological measurements over five years (2009-2011 and 2014-2015). Results show that droughts caused both immediate and prolonged effects on the lake carbon flux. GPP and R largely declined and both lakes were autotrophic CO_2 sinks or neutral during the dryer year (2014), but rapidly shifted towards net heterotrophic CO_2 emitters in the subsequent normal year (2015).

Changes in CO_2 fluxes were more sensitive to precipitation variations in the mesotrophic clear lake, due to inter-annual DOM fluctuations differentially affecting nutrient and light availability, as well as lake acidity, than in the colored, oligotrophic lake. DOM concentration, nutrient availability, and lake acidity also determined the production of endogenous labile organic materials that support lake respiration, and thereby influenced the amount and form of dissolved inorganic carbon (DIC) that, in turn, shaped the direction and magnitude of CO_2 flux. Results demonstrate that terrestrial loads of DOM serve as a driver for the response and sensitivity of ecosystem carbon flux to variation in inter-annual precipitation. Results of this study have important implications for predicting the trend, magnitude, duration, and sensitivity of the response of subtropical lakes/reservoirs function to future changes in precipitation patterns under an altered climate.

07-P Iron vs NOM light absorbance.

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The effect of colloidal ferric iron associated to NOM is multifaceted. Both iron and organic chromophores of NOM contribute to the color of water, but their relative contributions are however poorly known (Xiao *et al.* 2015). Iron chemistry in streams and lakes include pseudo stabile colloid fractions, and fractions are strongly pH, temperature and redox dependent regarding their solubility (Maloney *et al.* 2005). Interpretations of iron's role in the brownification process is hence not straight forward. Here, we present UV/VIS absorption spectra of Fe (III) in solution and in suspension, with and without the presence of NOM. UV/VIS absorbance of dissolved ferric nitrate, in filtered and non-filtered solutions in RO water, with and without additions of NOM has been measured. NOM was derived from a lake in SW-Norway, and from a freeze-dried isolate from a headwater catchment in S-Norway.
In solution, total absorbance measured equals the individual absorbance of iron added to the absorbance to NOM. This is similar to what was noted by Poulin *et al.* (2014). The ferric absorption spectrum at about pH 5.5, follows the characteristics of Fe $(OH)_2^+$, with a local minima close to 260 nm. This is close to the mercury lamp wavelength 254 nm, used in quantitative NOM measurements for UV-absorbance, and for the sUVa index (abs254/DOC). This is also close to the E2 wavelength (255 nm) used in E2/E3 and E2/E4 indexes, reflecting the presence of aromatic structural units or UV spectra slopes. From this, it is obvious that UV-absorbance and the sUVa-index will increase, and E2/E3 and E2/E4 will decrease, if not corrections for ferric iron absorption are made.
Ferric iron will exist in suspension for a short period of time, but for a considerably longer time in the presence of NOM. Inorganic (potential non soluble) iron species can be stabilized in solution by NOM of various quality (Gaffney *et al.* 2008), and a substantial Fe pool is likely bound or associated to NOM as Fe(II) or Fe(III), or in the form of oxy-hydroxide nanoparticles (i.e. Neubauer *et al.* 2013). More effort should be put into this specific field of study, also including more laboratory and *in situ* studies.

08. Global changes and aquatic ecosystems

08-O Impact of climate warming on inland waters. Past, present and future development. *Martin T. Dokulil*

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Long time series, in some cases dating back to 1901, of surface water temperatures (SWT) from lakes, rivers and groundwater from the yearbooks of the Hydrological Service Austria are analysed. Annual average, maximum and minimum temperatures as well as their range are analysed for trend, regime shift and variability. Different seasonal developments are exemplified in some cases. Changes in SWT are augmented with earlier observations on temperature changes in the hypolimnion of lakes (HWT), changes in the shape of profiles, onset and extent of stratification, and their possible consequences for fresh-water organisms. Results indicate significant increase of SWT in most of the cases from 22 lakes in Austria. Warming of streams and rivers is demonstrated using the Austrian section of the River Danube and some of its tributaries covering the period 1901–2015. These data are related to air temperature, precipitation and discharge. Significant relations of air to water temperature are established at all stations. Increments in groundwater temperature are shown for several sites. Teleconnection to climate indices such as the North Atlantic Oscillation (NAO) are used to find causal relations. Extrapolation of changes in SWT to the near future (2050) are calculated using different scenarios.

08-O The contributions of climate changes and human activities to long-term variations in lake sediments based on results from generalized additive models.

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Climate changes and human activities can influence lake sediments, which may lead to disruptions in aquatic environments, and a better understanding of these effects is crucial for the future management of lakes and reservoirs. Climate change and human activity factors such as air temperature, land use patterns, population size, and gross domestic product (GDP) were considered in this study of lake sediments in China. A generalized additive model (GAM) statistical approach was applied to assess the relationships among climate change, human activities, and sediment variables, namely, total organic carbon (TOC), total nitrogen (TN), and total phosphorus (TP) in Lake Chaohu and Lake Chenghai. Both lakes are located in climate sensitive areas, where the annual average temperature has risen over 1°C during the past three decades. The impacts of climate changes and human activities on TOC, TN, and TP were quantitatively interpreted with the results of the GAMs. The results indicated that the contributions of air temperature to variations in the sediment variables were significant (air temperatures can influence lake temperatures, which can have corresponding effects on the biota and sediments) but smaller than the contributions of human activities (e.g., percent of urban and paddy land, population size, GDP) in both lakes. The fitness of GAMs were all better than comparisons performed by stepwise linear regression. These findings demonstrate that GAMs are an effective approach for estimating the impacts of climate change and human activities on TOC, TN, and TP in lake sediments.

08-O Recent ^{210}Pb, ^{137}Cs and ^{241}Am accumulation in an ombrotrophic peatland from Amsterdam Island (Southern Indian Ocean).

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Over the past 50 years, ^{210}Pb, ^{137}Cs and ^{241}Am have been abundantly used in reconstructing recent sediment and peat chronologies (*Guevara et al., 2003; Bao et al., 2010*). The study of global aerosol-climate interaction is also partially depending on our understanding of ^{222}Rn-^{210}Pb cycling, as radionuclides are useful aerosol tracers. However, in comparison with the Northern Hemisphere, few data are available for these radionuclides in the Southern Hemisphere, especially in the South Indian Ocean. A peat core was collected in an ombrotrophic peatland from the remote Amsterdam Island (AMS) and was analyzed for ^{210}Pb, ^{137}Cs and ^{241}Am radionuclides using an ultra-low background gamma spectrometer placed at the LAFARA underground laboratory. The ^{210}Pb Constant Rate of Supply (CRS) model of peat accumulations is validated by peaks of artificial radionuclides (^{137}Cs and ^{241}Am) that are related to nuclear weapon tests. We compared the AMS ^{210}Pb data with an updated ^{210}Pb deposition database. The ^{210}Pb flux of 98 ± 6 Bq·m^{-2}·y^{-1} derived from the AMS core agrees with data from Madagascar and South Africa. The elevated flux observed at such a remote location may result from the enhanced ^{222}Rn activity and frequent rainfall in AMS. This enhanced ^{222}Rn activity itself may be explained by continental air masses passing over southern Africa and/or Madagascar. Consequently, the ^{210}Pb flux at AMS is higher than those derived from cores collected in coastal areas in Argentina and Chile, which are areas

dominated by marine westerly winds with low ^{222}Rn activities. We report a ^{137}Cs inventory at AMS of 144 ± 13 $Bq \cdot m^{-2}$ (corrected to 1969). Our data thus contribute to the under-represented data coverage in the mid-latitudes of the Southern Hemisphere.

08-O Illuminated waters in a modern world: Effects of artificial light at night on benthic primary producers.

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Increasing use of artificial illumination has transformed nocturnal environments over the last century. Natural light-dark cycles that have been stable over geological and evolutionary time scales are being disrupted by electrical lights. Today, artificial light at night is recognized as a contributor to global change and a biodiversity threat, as the evidence for its impacts on microorganisms, flora, fauna and human health is accumulating. Ecological impacts in illuminated waters, in particular at the base of the food web are, however, still largely unexplored.

My research focuses on effects of low-level nocturnal illumination on benthic communities of primary producers, the periphyton. We mimicked light conditions of urban and sub-urban areas in manipulative field studies and laboratory experiments to assess impacts of different light types (white LED and high-pressure sodium lamps) and light intensities on biomass and community composition of periphyton in different aquatic habitats. We found changes in biomass and in the proportions of major groups (diatoms, green algae and cyanobacteria) as well as taxon-specific responses. These changes may hinder primary production as a vital ecosystem function and therefore have consequences for higher trophic levels. We conclude that impacts of nocturnal illumination on aquatic primary producers must be considered when designing lighting schemes near water bodies in order to minimize adverse effects of artificial illumination.

08-O Past, current and future ecosystem and biodiversity trends of saline lakes in Europe and Central Asia.

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This review is partly based on the report on Europe and Central Asia (ECA) prepared by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). We assessed the effect of direct drivers (climate change, land use, pollution, resource exploitation and invasive species) on indicators of ecosystem health and biodiversity (habitat area, habitat degradation, species richness and endangered species). There is no comprehensive assessment on changes of biodiversity in saline lakes in ECA. Many saline lakes in the region experience large fluctuation cycles of water level and salinity with corresponding biodiversity shifts. The main driver of dramatic biodiversity decline of saline lakes in ECA is water withdrawal, which led to the decline of lake area, rise in salinity and destruction of fish spawning areas and species' migration routes. Another factor that contributes to decline of water level is climate change. It affects salinity level and leads to decline in biodiversity up to the total extinction of the majority of species. There is also an on-going process of salinization in the region. Some large saline lakes have a long history of isolation and serve as refugees for rare and endemic species. These species suffer from invaders which either reached saline lakes accidentally or were intentionally introduced (e.g. to improve fishery). There are several key messages of the review. Water level

decline driven by unsustainable water demand results in large ecological crises (e.g. desiccation of Aral Sea). The unique endemic biodiversity of large saline lakes suffer from water pollution, overfishing and invasive species (example of Caspian Sea). Aridization affects many lakes in the region with related changes in water level, salinity, biodiversity and ecological state. Integrated water resource management as well as conservation measures and introduction of climate-smart agriculture are basic conditions for the sustainable use of saline lakes in the region.

08-O Phenotypic plasticity in life-history traits of *Brachionus calyciflorus* across a gradient of salinity.

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Many lakes and reservoirs are challenged with increasing salinity as a result of climate change or urbanization. One of the adverse effects of increasing salinity on freshwater ecosystems is to threaten life and reduce biodiversity. Under salinity variation, phenotypic plasticity within species has a significance for its adaptation and evolution. Yet little is known about the mechanisms behind phenotypic plasticity of freshwater animals in response to salt stress.

Here we assessed the life-history traits in four clones of the rotifer *Brachionus calyciflorus* under different salinities. The goal is thus to understand the possible mechanism underlying phenotypic plasticity of rotifer in response to increasing salinity. Four clones (Clone 1, Clone 2, Clone 3, Clone 4) and six salinity levels (NaCl) were employed in this experiment. Average growth rate for all clones appeared to be the maximum at zero salinity, and tended to decrease with increasing salinity. Under six salinities, Clone 1 always had low growth rate, birth rate, and fraction of females with amictic eggs compared with Clone 3 and Clone 4, whereas it always appeared to be high in fecundity, resting eggs per female, fraction of females with mictic eggs relative to Clone 3 and Clone 4. Interestingly, Clone 3 and Clone 4, which were from the same waterbody, showed a similar trend for every trait across the salinity gradient. Growth rate was negatively correlated with death rate. Overall, different clones exhibited quite different life-history traits when confronted with different salinities. Our results suggest that life-history traits can partly explain phenotypic plasticity of zooplankton under salinity change.

08-O Ecological effects of invasive mosquitofish (*Gambusia affinis*) in Hong Kong fresh waters: a mesocosm approach.

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Invasive alien species are one of the causes of biodiversity decline. In fresh waters, mosquitofish (*Gambusia affinis*, together with the congeneric *G. holbrooki*) is a particularly successful invader. It has been introduced globally for controlling mosquito larvae, but consequential negative impacts on freshwater ecosystems have resulted in its inclusion on the IUCN list of the world's 100 worst invaders. Nonetheless, knowledge of the impacts of mosquitofish over much of its introduced range, especially in the tropics, is inadequate. For instance, we do not know how the ecological effects of mosquitofish differ from those exerted by other trophically analogous invasive and native species.

Research in Hong Kong (22oN) investigated the effects of mosquitofish on 1) macroinvertebrate assemblages, 2) biomass of primary producers (phytoplankton and periphyton), and 3) nutrient concentrations (nitrate, nitrite and ammonium). These effects were compared with those exerted by the guppy (*Poecilia reticulata*) – another globally invasive poeciliid - and two native fishes: the rice fish (*Oryzias curvinotus*) – which occupies similar spatial niche to mosquitofish - and a mid-water cyprinid, the Chinese barb (*Puntius semifasciolatus*).

Ex-situ mesocosm experiments were conducted in both wet and dry seasons. Each mesocosm contained 3 individuals of one of the four fish species; control mesocosms contained no fish. Each

of the 5 treatments had 7 replicates.

Mosquitofish and Chinese barb significantly reduced macroinvertebrate abundance (relative to control) during both seasons; guppy and rice fish had smaller effects. Mosquitofish also significantly reduced macroinvertebrate richness during both seasons, while Chinese barb and guppy had caused smaller reductions; the effect of rice fish was undetectable.

None of the fishes had any influence on primary-producer biomass or nutrient levels. In this mesocosms study, mosquitofish was plainly a more influential structuring agent than trophically analogous native species or the invasive guppy.

08-O Reduced detection distance or easier turn at less viscous medium: two possible reasons why warming increases the number of apparent prey in reaction field volume of zooplanktivorous fish.

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It has been recently shown for two small-bodied planktivorous fishes (juvenile rudd and Malabar danio) that the reaction distance (a distance from which the zooplankton prey can be spotted by a foraging fish) is greater at higher than in lower temperature, this resulting in an increased number of apparent prey within the reaction field volume of fish (Gliwicz et al. 2018). However, no any successful experiments have been so far performed to see which of the two possible reasons is more important for the increase in the number of apparent prey in reaction field volume of a zooplanktivorous fish. Here we test the first of the two possible reasons by estimating the maximum distance from which a larval zebrafish could see an approaching object that might be regarded as a prey item. This distance was estimated at the moment of the first neural response to a visual stimuli: we checked whether the extended reaction distance at greater temperature would result from the extended detection distance (DD) at elevated temperature. The DD was estimated at the time of first occurrence of the neural signal in the optic tectum (responsible for the processing of visual stimuli) expressing green fluorescent protein probes in transgenic zebrafish larvae exposed to a view of a moving image on the miniature OLED screen which simulated a prey item appearing in visual field of larval fish. Neural signals were recorded using selective plane illumination microscopy. We observed that the detection distance was rather shortened than increased with increasing temperature, thus suggesting that the easier turn towards the prey at less viscous medium might be a more likely explanation.

08-O The structuring role of submerged macrophytes and its response to global warming.

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Submerged macrophytes are important structuring components in shallow lakes, and warming will influence their growth and metabolic rate reproduction, abundance and competition with periphyton and phytoplankton. We conducted a series of mesocosm experiments to elucidate the structuring role of submerged macrophytes and its response to global warming. A winter experiment comparing the periphyton community on macrophytes with contrasting morphologies found that, both for natural and artificial macrophytes, the periphyton biomass was positively associated with leaf fractal dimension and periphyton composition differed. Another experiment conducted in four seasons comparing the periphyton responses to nutrient, temperature and plant type showed that, the periphyton community were significantly affected by nutrient and temperature in spring and summer but differed significantly among plant structure complexity in autumn and winter. Besides, a two-month warming experiment in winter found that, elevated temperature significantly decreased the biomass and changed the composition of the phytoplankton in the absence of *P. crispus*, while had little or no effect on phytoplankton when *P. crispus* was absent. Another five-month warming experiment (starting in winter) was conducted to elucidate the responses of macrophyte-periphyton-phytoplankton to elevated temperature under eutrophic, subtropical conditions. Results suggested that warming reduced the survival of *P. crispus* and increased phytoplankton biomass, but had no effects on periphyton. At the end of the experiment, a shift occurred from a clear-state dominated by *P. crispus* to a clear-state dominated by filamentous algae and warming facilitated this shift.

These results suggest that the morphological structure and physiological activity of submerged macrophytes may influence periphyton/phytoplankton community and water-column ecosystem. However, these effects were affected by warming and differed among seasons.

08-O The effect of whole stream warming on invertebrate drift in arctic geothermal streams.

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To predict responses to stream water warming, we studied insect drift in a upper reach (5.8°C) and a heated up lower reach (9.1°C) of a spring-fed stream and an adjacent warm stream (19-22°C) in a the geothermal area in Hengill volcano, Iceland. Chironomidae larvae dominated the drift in the unheated and heated reaches, being 10 times higher than the second abundant group, *Simulium vittatum*. *Radix balthica* (Gastropod) dominated the drift in the warm stream. Density of drifting insects fluctuated in the unheated reach of the streams, but it was stable in the heated reach and the warm stream. Drift density was similar in both reaches, but lower in the warm stream. There was no or little association between the drift of pupae and adults and emergence. Drifting Chironomidae larvae peaked in late June, late July and late August in the cold reach, and in the warm stream in early August. No such peaks were observed in the warmed up reach.

Warming up stream water by 3.3°C did not alter invertebrate drift densities. Differences could be related to cover of algae and mosses in the warm-up reach and stream stream.

08-O Climatically modulated decline in wind speed may strongly affect water quality in shallow lakes.

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Surface wind speed has declined significantly globally. However, the response of aquatic systems to decreasing wind speeds has received little attention. We examined the effects of a long-term decrease in wind speed on shallow, eutrophic Lake Taihu, China's third largest lake, by combining high-frequency monitoring, long-term meteorological and water quality data with short-term laboratory sediment nutrient release experiments. The high-frequency monitoring data showed that stratification and bottom water hypoxia occurred occasionally, when the disturbance index (DI), defined as the wind speed divided by the water level, was < 1. The annual mean DI showed a significant decreasing trend and the maximum continuous days with DI < 1 (DIdayM) increased significantly from 1996 to 2016, indicating that the lake became more vertically stable. The water quality data combined with the experimental results suggest that less disturbance and more persistent stability can enhance the release of phosphorus (P) from the sediments and increase nitrogen (N) losses, likely via enhancing denitrification, because a longer stability period leads to lower dissolved oxygen concentrations near the lake bottom. The results of Bayesian functional Linear regression with Sparse Step functions (Bliss) indicated that water stability during spring and summer strongly affect chlorophyll a (Chla) concentrations throughout the year by enhancing the release of nutrient from the sediments. The results of the structural equation models indicated that intensified water stability might increase phytoplankton biomass (as Chla) by altering nutrient availability. Increasing water temperatures and decreasing wind speeds synergistically enhance water column stability, which may offset some of the immediate benefits of reductions in external nutrient loading by enhancing internal loading. Given anticipated global warming, it is even more important than at present to reduce the external nutrient loading for overall improvement of water quality in this and other shallow eutrophic lakes.

08-O Cross continental increase in methane ebullition under climate change.

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Methane (CH_4) strongly contributes to observed global warming. As natural CH_4 emissions mainly originate from wet ecosystems, it is important to unravel how climate change may affect these emissions. This is especially true for ebullition (bubble flux from sediments), a pathway that has long been underestimated but generally dominates emissions. Here we show a remarkably strong relationship between CH_4 ebullition and temperature across a wide range of freshwater

ecosystems on different continents using multi-seasonal CH_4 ebullition data from the literature. As these temperature–ebullition relationships may have been affected by seasonal variation in organic matter availability, we also conducted a controlled year-round mesocosm experiment. Here 4 °C warming led to 51% higher total annual CH_4 ebullition, while diffusion was not affected. Our combined findings suggest that global warming will strongly enhance freshwater CH_4 emissions through a disproportional increase in ebullition (6–20% per 1 °C increase), contributing to global warming.

08-O Habitat type affects the stress response of Eurasian otter (*Lutra lutra*) in Gwangju stream and Jangan stream. *Gun-ju Lee*

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The stress response has many effects on the survival of wild animals in various environments. Stress responses can be determined by hormone levels, such as corticosterone or cortisol, that are released when wildlife is exposed to stress conditions. This species, Otter, is a member of the otter subfamily of the weasel family, and one species of Eurasian otter is inhabited in Korea. The first species of endangered species in South korea, the otter, lives mainly in the water and is a top predator in the aquatic ecosystem and is often used as an indicator of ecological health. In Korea, studies on otters have been carried out, but most studies have only confirmed the presence or absence of using the fecal trace. Therefore, in this study, we confirmed the tendency of the concentration of stress hormone using otter feces according to the habitat characteristics of Gwangju Stream and Jangan Stream. The method of confirming the concen -tration of stress hormone by using feces is advantageous in that there is no stress due to trapping. This study was carried out from October, 2017 to December, 2017, and collected a total of 65 otter fecal from Gwangju and Jangan. Mean width, mean altitude, mean temperature, and land cover of Gwangju and Jangan stream were measured and compared with the concentration of stress hormone. The habitat factors of Gwangju stream and Jangan stream showed a significant difference, but the stress hormone concentrations did not show any significant difference. However, habitat factors and stress hormone concentrations were significantly different in the upper, middle, and downstream areas of Gwangju stream.

The results showed that the lowest stress hormone levels were observed in the downstream area of Gwangju stream, which had larger width, lower altitude, higher temperature, higher barren land rate, inland water and inland wetland rate, and less mountainous area rate than other areas. This result shows that the habitat of the water system and the food resources of the otter mainly affect the stress response of the otter.

It can be confirmed that otters live in many places, and it is expected that this will be the baseline data for future attempts to preserve and restore habitat of otters in the future by confirming the stress response to the habitat, not only the existence of otters.

08-O Modelling shifts in the carbon balances and GHG exchange of some types of Mediterranean temporary wetlands under different RCP climatic scenarios. *Antonio Camacho*, Antonio Picazo, Carlos Rochera, Anna C. Santamans, Daniel Morant, Javier Miralles-Lorenzo*

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Because of its permanent or temporal water cover, the rates of biological activity in aquatic ecosystems can be very high, thus having a high capacity to process carbon, with an

overrepresented role on the global carbon cycle relative to its surface coverage. Among biological activities, photosynthesis is the main process contributing to carbon removal, whereas aerobic and anaerobic respiration release CO_2, though under very low redox conditions methanogenesis merges as the main respiratory process. Wetlands are important sources of methane, but the capture or release of CO_2 either by photosynthesis or respiration, respectively, also contribute to the carbon balances and thus influence climate change. The global warming potential of CO_2 is lower than that of methane at short-medium term, so the relative influence of biological carbon processes on the global carbon cycle and its warming potential is different. In this work we evaluated the main biological processes related to the carbon cycle in semiarid Mediterranean temporary lakes and wetlands located in Spain, some of which are kept under natural conditions, whereas other are altered. Additionally to the field measurements, we performed controlled experiments where the specific role of temperature, salinity, and hydrological conditions on these biological processes was evaluated and modelled. On this basis, and also supported by models of the ecohydrological response of the studied wetlands to the four climatic scenarios predicted by the IPCC, we forecast that because of the predicted climate changes in these semiarid environments, the carbon budgets of the studied wetland types could be unbalanced. Some of them, especially if their natural conditions are altered, could change from net carbon sinks to net sources and, moreover, they disproportionately increase methane emissions. Wise management modes are of paramount importance to balance the possible negative effect of climate change on the carbon-sequestering capacity of the studied wetlands.

08-O Sensors reveal flipping of biogeochemical behavior in a small tropical river after major hurricanes.

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Stream chemistry has been studied intensively for 35 years in the tropical rain forest of Puerto Rico. Past work with weekly grab samples shows that at high flows major ions rapidly dilute, DOC increases, and nitrate remains stable in concentration. We have also shown that nitrate and potassium concentrations are continuously elevated for several years after the passage of major hurricanes, and only return to baseline levels when vigorous tree growth is re-established. Here we report the impacts of Hurricanes Irma and Maria (September 2017) on the chemistry of Quebrada Sonadora in the Luquillo Mountains of Puerto Rico for the first 6 months after these two major storms using in situ sensors to obtain a 15-minute record. As expected, turbidity during Maria was the highest in our sensor record (> 1000 NTU) and nitrate concentrations increased a few months after the storm. Contrary to our expectations, however, we found that the behavior of many solutes in response to discharge was radically changed after the major hurricanes. Specific conductance flipped from a consistent dilution response during high flow to an enrichment response both during and after Maria, suggesting that marine aerosols were deposited during the hurricane and flushed from the soil profile for several months after the storm. Nitrate also flipped its behavior for at least several months after Maria, with large concentration increases (up to 1.8 mg N/L) at high stream discharge observed during even small rainstorms. The flipping of nitrate behavior in response to modest rain storms, from source limited to transport limited, suggests that these two severe hurricanes have fundamentally altered the nitrogen cycle at the site in ways that would not be evident without sensors.

08-O Pulsed release of nutrients and organic matter during simulated rewetting events in intermittent rivers and ephemeral streams: a global analysis.

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Global climate change and human pressures increase the proportion of intermittent rivers and ephemeral streams (IRES), which already comprise half of the global river network. Rewetting events in IRES cause a pulsed release of nutrients and organic matter (OM) from materials accumulated during dry phases. Yet, global-scale knowledge on the quantity and quality of released dissolved substances and on driving environmental variables is missing. We experimentally simulated rewetting events using leaves, epilithic biofilms and riverbed sediments, collected during the dry phase from 205 IRES globally as part of the "1000 Intermittent Rivers Projects" (https://1000_intermittent_rivers_project.irstea.fr). We determined the quantitative and qualitative characteristics of the released nutrients and OM and estimated their areal fluxes from riverbeds. In addition, we evaluated to which extent selected environmental variables and characteristics of accumulated substrates explain variance in characteristics of the leachates. Concentrations of nutrients and OM released per g of substrate peaked from leaves (apart from nitrate) followed by biofilms and riverbed sediments. Leachates with the highest qualitative characteristics in terms of potential bioavailability (low aromaticity, high content of biopolymers) were released from biofilms. On the global scale, dissolved organic carbon, phenolics, and nitrate dominated the flux upon rewetting. Sediments were the main contributors to areal fluxes of nutrients and OM from riverbeds (56-98% depending on analyzed substances) due to their higher mass within the riverbeds. The highest concentrations, but with the lowest aromaticity of OM, were released in the continental climate zone. The selected nine environmental variables predicted the highest percentage of variance in quantity of leachates for sediments in continental (59%) and tropical (46%) zones. We conclude that rewetting events in IRES are key moments in ecosystem processes due to a pulsed release of nutrients and OM, whose quantity and quality can be further modulated by environmental variables under climate change.

08-O Impacts of climate change and land use on the development of nutrient criteria.

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Numeric criteria are crucial for controlling cultural eutrophication and for protecting current and future water quality. Anthropogenic climate change and the modification of land use have the potential to influence the development of nutrient criteria. In this study, stressor-response models, land use-nutrient regression models, and terrestrial ecosystem health states were used to determine the criterion values of total nitrogen (TN), total phosphorous (TP), and chlorophyll a (Chl α) using field data from lakes and reservoirs in Heilongjiang Province. Analysis of covariance and

nonlinear regressions were used to quantitatively characterize the impact of climate change on the development of nutrient criteria. The results indicated that there were no significant differences in the nutrient criteria obtained by the various methods. Climate change factors (such as temperature, precipitation, and wind speed) are predicted to influence the relationships between nutrients and Chl α, as well as land use and nutrient concentrations, as climate change persists. Climate change should be considered during the development of nutrient criteria, as climate-driven change and achieving a desired water quality without the threat of eutrophication in the future will require stricter nutrient criteria than those needed under the current climate conditions.

08-P Estimation of lake water temperature based on the theory of stochastic process -Examples in Lake Inba.

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Various schemes for water issues are adopted by Paris Agreement and Sustainable Development Goals (SDGs) among other meetings over the world. In Japan, The Basic Act on the Water Cycle was promulgated. They were reported that the management of the entire basin was important. In this article, Lake, which is one of the basin, as a subject, for example Lake Inba (In Chiba, Japan), we estimated lake water temperature including the uncertainty by using heat budget method. Lake Inba is very shallow lake. Its mean depth is 1.7 m and maximum depth is 2.2m. It has the role of flood control and four kinds of water use or utilization; clean water, agricultural water, inner water surface fishery and industrial water. In this way, having several roles Lake Inba is rare in the world. Therefore, the change in the lake environment affects many things. So, we estimate water temperature to understand the lake environment. But there are a lot of uncertainty factors which would affect the analysis result of water temperature very seriously. So, the authors would consider the variability of atmospheric phenomena: atmospheric temperature, sunshine duration and so on, or heat flux on heat budget method and estimated water temperature by using the probability theory. And we studied the variability of estimated water temperature by the variability of every atmospheric phenomenon or heat flux.

08-P Combined effects of elevated epilimnetic temperature and metalimnetic hypoxia on the foraging rate of planktivorous fish.

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Numerous studies have shown that elevated temperature results in a decrease of mean body size in zooplankton populations and communities, either spatially or temporally. One of the mechanistic explanations of this phenomenon is based on the fact that increased temperature in the epilimnion and decreased oxygen concentration (hypoxia) in the metalimnion decreases the thickness of the metalimnetic refuge for zooplankton.

We verified this hypothesis in 24 experiments with planktivorous fish (juvenile rudd, *Scardinius erythrophthalmus*), foraging on two age classes of *Daphnia longispina*, in a setup comprised of nontransparent columns (H = 170 cm, 45 cm in diameter), which allowed us to establish the same gradients of light intensity and algal food in both columns, but different gradients of temperature and oxygen concentrations. In each experiment, the control treatment (normoxia throughout the water column and temperature gradient from 18 ºC in the epilimnion to 8 ºC in the hypolimnion) was in one column, and one of the four experimental treatments was in the second column, differing from the control treatment by: (1) elevated temperature in the epilimnion, (2) the presence of hypoxia in the meta- and hypolimnion, (3) the presence of hypoxia, as well as *Daphnia* and fish acclimated to hypoxia before the experiments, (4) both higher

temperature in the epilimnion and hypoxia in the meta- and hypolimnion.

The results confirmed our hypothesis that the foraging rate of fish on both age classes of *Daphnia* was the smallest in the control treatment and the greatest in the third and fourth treatments. While the elevated epilimnetic temperature increased the mean depth selected by the fish to a greater extent than by the *Daphnia*, the presence of meta- and hypolimnetic hypoxia decreased the mean depth selected by the *Daphnia* to a greater extent than by the fish.

08-P Factors describing lake dissolved organic carbon at a global scale.

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Lakes comprise only 4% of the Earth's land surface. Nevertheless, they play a crucial role in the global biogeochemical cycles, contribute to climate regulation, provide diverse habitats, support biodiversity, and are valuable sentinels of global environmental change. The necessity to understand and predict climate requires a solid comprehension of the global carbon cycle. The regulatory service of lakes in carbon cycling is disproportionately important relative to their small areal extent and lakes act as carbon hot spots in landscape. Dissolved organic carbon (DOC) has an important role in the carbon and energy cycle of lakes and factors controlling the DOC concentrations in lakes and also the export from the catchment, are of great interest. Therefore, it becomes interesting to investigate which factors relate most closely to the lake DOC content. Such factors may involve (1) the physical and spatial properties of the catchment; (2) morphometric characteristics of the lake; (3) climatic properties and (4) atmospheric conditions. Although, the relationships between DOC and its main controlling factors in lakes have reached a great portion of attention during the last decades, there are very limited studies at a global scale. In this study we used the novel machine learning technique Boosted Regression Trees, HydroLAKES and other global databases to test if and how the factors above contribute to the variability of *in situ* DOC in lakes globally.

08-P Effects of Simulated Acid Rain on pH in Lakes with Different Trophic Levels.

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pH has important effects on aquatic organisms and the element cycling in lakes. The south part of the middle and lower reaches of the Yangtze River is the center of acid rain in the world. The effects of acid rain on lake pH were studied through the field investigation and simulated experiment. In the 68 investigated lakes along the middle and lower reaches of the Yangtze River, lake pH had a significant positive correlation with water temperature, dissolved oxygen and chlorophyll a, and a significant negative correlation with total nitrogen, nitrate, dissolved inorganic carbon and turbidity; the average pH value of lakes in acid rain areas was significantly lower than that in non-acid rain areas ($p < 0.05$). The results of the simulated experiment showed that the pH value of the low trophic treatment (L)was lower than that of the high trophic treatment (H), and the increasing rates of pH in L treatment was slower than that in H treatment after the single addition of the acid rain (pH = 2.5, 4.0 and 5.0). The differences of the pH values with three pH treatments of acid rain decreased over time in both L and H treatments. The daily variations of

the pH values with different treatments showed the same trend. At the end of experiment, the pH values with acid rain addition and no acid rain addition had no significant difference in the two trophic treatments. Our study indicated that although the increase of the content of chlorophyll a in lakes caused by eutrophication can enhance the buffer capacity of the acid rain, the persistent acid rain could have a potential impact on pH, aquatic organisms and biogeochemical cycles in lakes of this areas.

08-P Influence of the regional climate variations on lake changes of Dangqiong Co, Bankog Co and Zabuye salt lakes in Tibet.

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The lake hydrological dynamic change and meteorological data of the Tibet Plateau are not rich. This research reports the observed climatic data and measured water levels of saline lakes from the local meteorological stations in the Zabuye salt lake area during 1991-2014 and the Dangqiong Co salt lake area during 2004-2014. Combining with satellite remote sensing maps, we have analyzed the changes of the water level of these two lakes in recent years and discussed the origins of the changes induced by the meteorological factors. The results show that the mean annual temperature and the water level reflect a general ascending trend in these two lakes during the observation period. The rising rates of the mean annual temperature were 0.11℃/year and 0.20℃ /year, and of the water level, were 0.032 m/year and 0.24 m/year, respectively. Analysis of changes of the meteorological factors shows the main causes for the increase of lake water quantity are reduced lake evaporation and increased precipitation in the lake basin by the rise of average temperature.

09. Macrophyte ecology and management

09-O The reproductive success of two species of native macrophytes is affected by the density of an invasive Poaceae.

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Plant resources can be allocated to different plant functions, such as growth, reproduction and defense. The targeting of these resources entails a compensation made by the plant. For example, when there is a limited amount of resources available to an individual, there must be a trade-off in directing resources for growth or reproduction ("reproduction cost"). *Urochloa arrecta* is an invasive species with recognized negative effects on aquatic communities but for which the effects on sexual reproduction of native aquatic plants are not known. In this work, we experimentally tested the competitive effects of *U. arrecta* on the sexual reproduction of two native species of macrophytes (*Pontederia cordata* and *Eleocharis montana*). We tested the hypothesis that increased competition between native and invasive macrophytes (caused by increasing the density of the exotic species) makes individuals of the former species to redirect more energy towards sexual reproduction. We found that increased competition caused a continuous decrease of biomass and reproductive structures of both native species. However, in low to moderate densities

of *U. arrecta*, both natives increased the biomass allocation for reproduction and shortened the time to first flowering. These results indicate that sites with high biomass of the invasive species are restrictive to the sexual reproduction of the native ones, decreasing their long-term persistence under these conditions. However, when the biomass of the invasive is low to moderate, native macrophytes still find conditions for sexual reproduction, since they accelerate flowering and redirect more energy to the formation of reproductive structures.

09-O Ecological stoichiometry of submerged macrophytes in freshwater lakes. *Wei Xing*

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Ecological stoichiometry is a powerful approach for examining the balance of multi-elements in ecological processes. This approach has pushed us for better understanding of trophic transfer and nutrient cycling in aquatic and terrestrial ecosystems. Though elemental stoichiometry of phytoplankton, zooplankton and fish in aquatic ecosystems have been studied extensively, submerged macrophytes in freshwater lakes have received less attention. Firstly, we studied ecological stoichiometry of submerged macrophytes collected from freshwater lakes in Yangtze floodplain and YunGui Plateau. Secondly, we further explored the driving factor in the pattern of the stoichiometric characteristics. Finally, we provided some implications for the lake management base on elemental stoichiometry.

09-O Physiological characters of macrophytes existing in water with different ammonium concentration. *Ling Xian*

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Nitrogen is a crucial nutrient for macrophytes, it is available to plants in the form of NO_3--N and NH_4^+-N. NH_4^+-N concentration in water bodies has increased recently due to increased anthropogenic influence, which has led to markedly stress effects on macrophytes, macrophytes have been characterized as NH_4^+-N sensitive or tolerant. The objective of this work was to explore macrophytes' physiological processes in water bodies with diverse NH_4^+-N concentration and make the physiological characters of macrophytes resistance on high NH_4^+-N concentration clearer. We investigated NH_4^+-N concentration and sampled macrophytes in water bodies across China, then measured and analyzed some physiological indexes such as NH_4^+-N contents, FAA and key enzymes activities. In polluted water with high levels of NH_4^+-N concentration, the diversity of macrophytes is deficient, however, *Myriophyllum spicatum* L. exists in almost all water bodies, the activities of NAD(P)H- dependent GDH in the leaves of *M. spicatum* is higher than other macrophytes, nonetheless, the activities of NAD(P)-dependent GDH are inactive in the leaves of most macrophytes. These results suggest that *M. spicatum* is one of the most NH_4^+-N tolerant submerged macrophytes species. *M. spicatum* is able to adapt to environments with high levels of NH_4^+-N concentration may be due to its ability to convert NH_4^+-N to glutamate through NAD(P)H- dependent GDH, which could also reduce the stress of high concentration levels of NH_4^+-N on *M. spicatum* in water. However, the characteristics of GDH and its function on macrophytes to resist NH_4^+-N still needs more detailed investigations.

09-O The limiting effects of turbidity and salinity on growth of Stuckenia pectinata in a degraded coastal lake. *Qian Hu[1], Ian Hawes[2]*

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Lake Ellesmere is a shallow coastal lagoon located on the east of the South Island of New Zealand and is periodically open to the sea. An extensive macrophyte bed once existed around the lake margins, which disappeared after a storm event in 1968, and never returned. Now the lake is highly turbid with light attenuation coefficient of ~10^{-m} and has fluctuating salinity varying from 3 to 21 ppt. A series of experiments were undertaken to understand how an indigenous macrophyte, *Stuckenia pectinata*, responds to light and salinity stress, which is of critical importance for attempts to manage re-establishment of a macrophyte bed.

When low light stressed, morphologically, *S. pectinata* etiolated to reach the better-illuminated upper water column sooner and produced lighter and longer leaves to increase its photosynthetic leaf area. Salinity stress reduced leaf production rates and induced early leaf senescence, leading to less photosynthetic leaf area. Physiologically, leaves at low irradiance level increased chlorophyll-a per leaf fresh weight (area) to enhance light harvesting efficiency, at the sacrifice of photosynthetic rates per unit chlorophyll-a (light conversion efficiency); whereas leaves at high irradiance level had less chlorophyll-a per fresh weight (area), but higher photosynthetic rates per unit chlorophyll-a (higher light conversion efficiency). High salinity levels (⩾12 ppt) limited the light conversion efficiency of leaves at high irradiance while had no effects on photosynthesis of leaves at low irradiance.

In conclusion, in the degraded lake, the growth of *S. pectinata* would be limited due to less photosynthetic leaf area in salinity stress, and due to constrained photosynthetic light conversion efficiency either by low-light stress in the water column or by salinity near the water surface.

09-O Factors affecting the within-plant morphological and photophysiological variability of a rooted submerged macrophyte, *Potamogeton perfoliatus*.

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The vertical pattern of traits in rooted submerged macrophytes is the result of an interaction of internal (morphogenesis) and external (light and periphyton) factors. In this study, attempt was made to identify the effectors accountable for this within-plant variability, thus morphological and photophysiological traits of *Potamogeton perfoliatus* were studied as a function of their position, light intensity within the water column and periphyton coverage. Results show that a very specific vertical pattern of morphological and physiological foliar traits exists in *P. perfoliatus* and that is persistent even within a large and environmentally divers lake like Lake Balaton. The also data suggest that morphological traits and foliar pigment content of *P. perfoliatus* are affected by partially by morphogenesis and irradiance, while photophysiological parameters change as a result of morphogenesis, light availability and periphyton cover of leaves. The obtained data could help to understand the role of morphological and physiological adaptations and acclimations to the environmental conditions and aids a better comprehension of the plant-environment interactions.

09-O Stocking of herbivorous fish in eutrophic shallow clear-water lakes to reduce standing height of submerged macrophytes while maintaining their biomass.

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To balance the conservation value versus recreational use of shallow lakes, moderate herbivory may be needed in eutrophic lakes to avoid near surface growth while maintaining high vegetation biomass close to the sediment. However, over-grazing or even complete elimination of macrophytes by grass carp (*Ctenopharyngodon idella*) commonly used for control purposes has often been observed, leading to a shift from a clear to a turbid phytoplankton-dominated state. We hypothesized that slow-growing and smaller-sized fish species might be more suitable than grass carp to obtain the desired moderate control because they consume the top part of the vegetation without severely affecting the lower plant parts. To test the hypothesis, the effects of Wuchang bream (*Megalobrama amblycephala*), an endemic medium-sized herbivorous cyprinid, and grass carp on the biomass, density and trait of the macrophyte *Vallisneria denseserrulata* were compared in an enclosure experiment. We found that *V. denseserrulata* grew less tall but did not lose biomass under moderate herbivory by Wuchang bream due to increased plant density, leaf number and leaf weight per length, whereas excessive herbivory by grass carp had strong negative effects on the plant biomass. Moreover, the plant had thicker leaves in the fish treatments than in the fishless controls. The growth of grass carp was much faster than of Wuchang bream. Our findings suggest that stocking of Wuchang bream in proper densities may be more useful than grass carp for the management of *V. denseserrulata* and likely also other macrophyte species. More tests, especially at different fish densities are, however, needed to draw any firm conclusions regrading this hypothesis.

09-O Effects of taxonomy, water nutrients and environmental factors on C:N:P stoichiometry of submerged macrophytes in Yunnan plateau lakes, China . *Su Hong*

Institute of Hydrobiology, Chinese Academy of Sciences, China

Carbon (C), nitrogen (N) and phosphorus (P) are the three most important essential elements limiting growth of primary producers. Plant nutrient concentrations and their stoichiometric characteristics are often used to predict nutrient availability and nutrient limitation. However, the C:N:P stoichiometric signatures of plant tissue are affected by many additional factors such as taxon, water nutrients and species composition, while different environments induce different species compositions. We collected 138 samples from 21 sites in Yunnan plateau shallow lakes of China along a latitude gradient, including 33 species from 17 genera and 15 families. We revealed the relative importance of taxonomy, water nutrients, and environmental factors on plant C:N:P stoichiometry using variance partitioning based on partial redundancy analyses. Results showed that taxonomy was the most important factor in determining C:N:P stoichiometry, then the water nutrients but the environment factors not significant. The C:P and N:P ratios found in aquatic macrophytes in the present study were lower than previous findings, likely due to higher concentration of P in the plateau environments. Based on our study, it is suggested that submerged macrophytes in Yunnan plateau shallow lakes are primarily limited by P-richness.

09-O Conditions for continuous cultivation of *Chlorella sorokiniana* for harvesting algal biomass and nutrient removal from anaerobic digestion effluent of macrophytes and food waste.

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Continuous cultivation of microalgae *Chlorella sorokiniana* using three 10 L panel bioreactors was conducted in different pH and hydraulic retention time (HRT) under natural light conditions, to determine the maximum yield of algal biomass and nutrients removal from 10-fold diluted anaerobic digestion effluent (ADE) using mixture of macrophytes and food waste, which contained high concentrations of ammonium (NH_4-N) and phosphate (PO_4-P) but less available magnesium (Mg). In the following experiments, Mg was enriched or pH was lowered in source ADE for flow-through culture system for increasing available Mg. Mg enriched experiments were conducted at 5 days of HRT in summer, and then temperature and dissolved oxygen (DO) concentrations varied in 23.1−30.8ºC and 3.4−7.3 mg L^{-1}, respectively; pH in the medium increased from 8.2 to 10.5 during day 1 to day 3, being constant of 9.4−10.9 during the following period; algal biomass gradually increased until day 12, being constant in ca. 0.7 g dry-weight L^{-1}, the biomass production was 0.14 g L^{-1} day^{-1}, > 94% of both NH_4-N and PO_4-P was removed from the ADE used. pH controlled experiments were conducted at 5 and 10 days of HRT in two different pHs, 5 and 6.5 of source ADE using LEDs as artificial light sources due to low solar radiation in autumn; temperatures and DO concentrations varied in 16.3−30.3 ºC and 4.5−6.9 mg L^{-1}, respectively; since no deficiency of available Mg due to low pH adjusted, the similar algal productions were obtained as those in the Mg enriched experiments, removal efficiency of NH_4-N largely fluctuated (ca. 30−100%) with algal biomass harvested among different pH and HRT conditions, whereas those of PO_4-P was always > 93% during the study period. Finally, 6.5 of pH in source ADE and 10 days of HRT would be appropriate condition through continuous culture of *C. sorokiniana* using the ADE.

09-O Allelopathic effects of blooming cyanobacteria on aquatic organisms.

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Cyanobacterial bloom has become a serious problem in the most inland eutrophicate lakes. *Microcystis* spp. normally dominates in the blooming water, resulting in ecological hazards in many aspects. Releasing harmful secondary metabolites is known as one kind of survival strategy for *Microcystis* spp. The allelopathic effects of this species, however, has been remained unclear. We chose a commen blooming cyanobacteria, *Microcystis aeruginosa*, to test the allelopathic effects on submerged macrophytes, fish, microbacteria and plankton. Both extraction and exudation obtain from different growth phase were tested. We found that: (1) Submerged macrophytes were obviously inhibited by allelochemicals from *M. aeruginosa*, and exudation were stronger than those of extraction. The early growth of seedlings were more sensitive to allelochemicals than seed germination; (2) *M. aeruginosa* exudates can significantly inhibit the growth of microorganisms; (3) The serious malformation of fish embryos were observed under *M. aeruginosa* exudation exposure; (4) Allelopathic inhibition of *M. aeruginosa* on a green algae was

enhanced by macrophyte allelochemical; (5) Some active substances from *M. aeruginosa* exudation, such as styrene and dimethyl disulfide, were determined as the potential allelochemicals.

09-P Compare submerged macrophytes coverage obtained by high resolution images processing and field sampling.

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Generally, one way we use to get coverage data is to set even distributed transects and sampling points then use an underwater viewer or by a diver to determine it, and in most cases, coverage were finally rated in reasonable categories, like 1-5%,5-25%,25-50% etc.. It's unfulfillable to get a precise number because the observation difference of different people. Furthermore, we can not get coverage data simultaneously in a large scale of space and time. It matters when we want to compare these data of one or more lakes from a long time series. In addition, for a large water body, it's usually expensive to do such business due to labor cost and etc.. In the experiment, we want to test and verify if high resolution images can be used as an alternative effective and sufficient way to determine coverage of submerged macorphytes in shallow lakes. And if so, what is the application condition. Try to provide a better way to acquire coverage data.

09-P The responses of ecological indicators to hydraulic operation forcing in Lakes.

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The competition between macrophytes and epiphyton in shallow lakes can be a crucial factor in a regime shift, between the macrophyte-dominated, clear-water state and the phytoplankton-dominated, turbid state. Macrophyte overgrowth in shallow lakes may lead to deterioration and a consequent necessity for restoration treatments. To investigate the effects of water-level fluctuations, flow velocity, and epiphyton growth on the growth of macrophytes using a mathematical model, the integrated Water Quality Model and modified Submerged Aquatic Vegetation Model (M-SAVM) were tested in two shallow reservoirs. Results showed that epiphyton increase had a slightly low light intensity limitation coefficient to suppress plant growth in M-SAVM. Significant negative correlation ($p<0.01$, $r=-0.97$) between biomass and water depth existed in the reservoir. The increased flow velocities enhanced macrophyte growth and dissolved oxygen concentrations concurrently with the decline of epiphyton biomass. Our study suggested the macrophyte model might serve as a useful tool to help maintain water transparency in similar shallow lakes.

09-P Diversity and coverage are more important than biomass of re-established submerged macrophytes in maintaining water quality in subtropical small shallow lakes.

Yiming Gao

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The re-establishment of submerged macrophytes is an important bottom-up bio-manipulation measure to restore eutrophic lakes. However, the macrophytes community might degrade within 3 to 5 years after transplantation. We hypothesize that the stability of macrophyte community and the ecosystem service function (such as maintaining a low nutrient concentration in overlying water) depend positively on the total biomass, diversity, and coverage of submerged macrophytes

community. Two small shallow eutrophic lakes at the lower reaches of the Yangzi River were planted submerged macrophytes with different initial total biomass, diversity, and coverage. Community changes and water quality were monitored monthly. The results showed that the biomass density and community diversity of macrophytes in the two lakes exhibited an upward trend in spring and summer in each year, but they reduced nevertheless compared with that in the same period last one or two years. The restoration area of Lake Wulihu with high initial macrophytes biomass and diversity showed less decreasing than the restoration area with lower initial conditions in Lake Qinhu. Meanwhile, the macrophyte coverage of Lake Wulihu maintained a high and changeless level during the sampling period, but the coverage of Lake Qinhu increased gradually. After one year of restoration, both two lakes emerged a dominant status of canopy-forming submerged macrophytes such as *Myriophyllum*, which was more preponderant in Lake Qinhu. Generally, the water quality of the two restored lakes improved significantly compared with those in unrestored areas in terms of transparency, total nitrogen, total phosphorus and chlorophyll *a*, and the improvement of Lake Wulihu was more evident. In addition, from the standardized path coefficient, the macrophytes diversity and coverage were indicated to be more effective than biomass in controlling nutrients concentration and improving transparency. Therefore, we conclude that maintaining a high coverage and diversity of macrophyte is a more important aspect than increasing macrophyte biomass possibly developing into canopy-forming dominance in the restoration of subtropical small shallow lakes.

09-P Preference and utilization of *Megalobrama amblycephala* graze on *Hydrilla varticillata* and *Vallisneria denseserrulata*.

Chunyu Yin

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In many temperate and subtropical small shallow lakes, the canopy-forming species *Hydrilla varticillata* grow faster and taller to shade the sunligh and thus compete and inhibit the growth of bottom-dwelling species *Vallisneria denseserrulata*. Some studies indicate that *H. varticillata* is preferred by herbivorous fishes due to the better food quality. While, we hypothesized that *Megalobrama amblycephala* might balance the competition by grazing more *H. varticillata* than *H. varticillata*. In a planted macrophytes pond, we use 2 m × 2 m nylon mesh to fence water areas with mono-*H. varticillata*, mono- *V. denseserrulata* and the mixture of two species. At the same time, we put same numbers and weights of the herbivorous fish *Megalobrama amblycephala* into the other group. Results showed that: the biomass accumulating ratios of *V. denseserrulata* decreased from -2.08% without fish to -49.79% with fish in mono-species planting experiment, and in mixing planting experiment from -86.95% without fish to -87.04% with fish. The biomass accumulating ratios of *H. varticillata* decreased from -67.99% without fish to -96.55% with fish in mono-species planting experiment, and in mixing planting experiment from -46.75% without fish to -91.29% with fish. The utilization ratios (body weight/ fresh weight of plant biomass loss) of M. amblycephala grazed on *V. denseserrulata*, *H. varticillata* and mixed macrophytes were 2.79%, 0.49% and 0.51%. Our results implied that, *M. amblycephala* can reduce the competitiveness of *H. varticillata*, and improve the growth of *V. denseserrulata*. Meanwhile, the utilization ratio of *H. varticillata* by *M. amblycephala* is much lower than that of *V. denseserrulata*.

09-P The burial depth and germination capacity of submerged macrophytes seed bank in Lake Taihu.

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The seed bank of submerged macrophytes might be buried deeply in sediments and it might be stored for many years. The number and burial depth of seeds determine the potential development of submerged vegetation. In recent years, a majority of submerged macrophytes have disappeared in Lake Taihu. For the purpose of exploring the distribution pattern and potential

germination of the submerged macrophytes seed bank in Lake Taihu, we collected 31 sediment cores in the area that where submerged macrophytes had been emerged in lake Taihu. Each sediment core was cut into 5 layers and cultivated for 8 months under the conditions of clear water in the laboratory. In addition, we carried out a one-month experiment in the incubator to explore the effects of different burial depths on the germination of submerged macrophytes (take *Vallisneria spinulosa* as an example). The results showed that 34 plants were germinated from 31 sediment cores. The germinating seeds were distributed in all the burial depth, and 44.12% of them germinated from the depth of 0~5cm, 38.24% from 5~10cm and 10~15cm, the rest 11.76% from the depth over 20cm. The main species of Taihu seed bank were 32.35% of *Vallisneria spinulosa,* 44.12% of *Charophyteae,* 11.76% of *Potamogeton crispus Linn.* And there were a few *Potamogeton malaianus* and *Elodea nuttallii* too. In the light-incubator experiment, the seeds germination rate was 40%~60% at 0cm depth but almost 0% over 5cm burial depths. The results implied that, the seed bank in Lake Taihu was rich in species but poor in number. And the seeds buried in deeper sediments more than 5cm were hard to germinate. Therefore, it's impossible to use seed banks to restore the submerged maocrophytes in Lake Taihu naturally.

09-P Are the "Twin Lakes" of San Pablo "identical"?

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There are a cluster of seven maar lakes in the small (197.56 km^2) town of San Pablo (Luzon Is., Philippines) that serve as important contributors to the livelihood of lakeshore residents through open water fisheries, aquaculture and ecotourism. Two of the seven - Lakes Yambo and Pandin, are dubbed as the "twin lakes of San Pablo" due to their close proximity (39.8 m apart, separated by a 212 masl ridge), relatively similar sizes (Lake Pandin: 240,000 m^2; Lake Yambo: 305,000 m^2) and depths (Lake Pandin: 61.75 m; Lake Yambo: 38 m). Furthermore, these two lakes are considered to be less impacted by extensive human activities as compared to the remaining five. In this paper, we present the results of an on-going (beginning in October 2016) monthly monitoring of selected limnological parameters (vertical profiles of pH, DO, conductivity, temperature, and methane as well as Chl a, and primary productivity) in both lakes. We also took note of the impacts of prevailing monsoons on the limnology of both lakes. The results show that the prevailing meteorological conditions influence lake dynamics of the twin lakes but at varying intensities, which may then be related to the topography of the surrounding watershed and their physical characteristics. Moreover, the results reflect the extent of how the topography of the watershed area can alter the characteristics of these lakes and how lower rates of aquaculture use has left these lakes in relatively pristine conditions compared to the other five lakes. This novel information on the limnology of the "twin lakes" of San Pablo may help in the continued sustainable use of these lakes and provide a better understanding of tropical maar lakes.

10. Fish and fisheries

10-O Genetic traces of historical fish stocking and translocations in contemporary whitefish (*Coregonus*) populations.

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Written reports on fish stocking and translocation for fisheries purposes in Middle Europe date back until the late 19th century. Accordingly, contemporary fish populations may be considered as indigenous although they may reflect assisted invasions from earlier centuries. We elucidated the complex history of Lake Schaal (northern Germany) whitefishes, for which studies from the early 20th century suggested numerous stocking or translocation events from various

sources, for example from Central European Lake Constance, Russian Lake Peipsi or from anadromous whitefish populations of the Baltic Sea. Analyses of 13 microsatellite markers from 15 contemporary whitefish populations unambiguously showed that Lake Constance whitefish are unrelated to any northern German whitefish population, including the contemporary whitefish population from Lake Schaal. Comparison with four historical specimens further showed that the native Lake Schaal whitefish *Coregonus holsatus* vanished from Lake Schaal, but has survived as an alien population by translocation into north German Lake Drewitz. The whitefish currently occurring in Lake Schaal and three other lakes nearby is *Coregonus maraenoides*, introduced from the Russian Lake Peipsi. Our study demonstrates that lake and anadromous whitefishes in Baltic and North Sea tributaries reflect a complex phylogeography, which is further blurred by the effects of repeated stocking and translocations. To identify evolutionary significant units for conservation, the genetic identity of each single population has to be scrutinized.

10-O Moving Towards Effective Governance of Freshwater fish and Fisheries.

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The public believe that the world marine fishery is suffering from a number of problems, such as overfishing, decline in fish diversity, unsustainable and ineffective fisheries management and environment damage. But for the freshwater fisheries, they have more. These include anthropogenic activities (eg., eutrophication, management of aquatic vegetation, river flow regulation), the use of fisheries enhancements (eg., stocking of hatchery fish) and widespread presence of non-native species. The paper outlines several fishery management approaches that can be adapted to a wide range of different freshwater fisheries and management challenges. They include maximum sustainable yield (MSY) assessment, individual transferable quotas (ITQ) determination, aquatic protected areas (APA) construction, reasonable biomanipulation and stocking and invasive fish species control. In the paper, we review the objectives, theoretical background, and practicalities of securing sustainable fishing and benefits for both resource and stakeholders in freshwater bodies.

10-O Influence of hydro-geomorphology on fish distribution in the middle reaches of Yangtze River, China.

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In natural situation, mainstem of middle and lower reaches of the Yangtze River was connected to many shallow lakes seasonally or permanently, which serviced as fish nurseries. Identification of the major nurseries in the river channel will provide critical information for fish conservation and management. Hydraulic and geomorphological variables are crucial factors determining fish distribution in river system. In this study, we investigated fish distribution in a river segment of a national reserve in the middle Yangtze River by combining hydroacoustics and geomorphological analysis. Our objectives were to reveal pattern of fish distribution in this segment and to identify the major environmental variables influencing such pattern. Two hydroacoustic surveys were carried out in October 2016 and May 2017 using a Simrad EY60 split-beam echosounder. Hydraulic variables were simultaneously collected using an Acoustic Doppler Current Profiler system. Geomorphologic variables were estimated with Arc GIS 10 software. Habitat types in reach scale (i.e., straight channel, meandering channel, island affected straight channel and island affected meandering channel) had significant influence on density of fish. Higher densities were observed in island affected meandering channels (1.19±0.06,

0.84±0.04), followed by meandering channel (1.10±0.13, 0.81±0.06) in both spawning and harvesting season. Habitat types also influenced preferred water column of fish distribution. In meandering channel and island affected meandering channel, fishes were highly distributed from 10-15 m and 5-15m depth respectively. Environmental factors among habitat types, such as water depth, sinuosity index, shoreline index, and width/depth ratio, were significantly correlated with density of fish; and effects of hydraulic variables, such as water depth average velocity and vertical average velocity, were different to fishes within different body-size groups. Our results suggest those habitats nearby islands and meandering river channel, which have geomorphological and hydrologic complexity, are more important for fish nursery and should be priority in management and conservation.

10-O Reproductive biology of *Toxabramis swinhonis* Günther, 1873 in a shallow lake (Biandantang Lake) along the middle reach of the Yangtze River basin (China): implications for fisheries management.

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The reproductive biology of thin sharpbelly, *Toxabramis swinhonis*, one of the most abundant bycatch species in freshwater fishery in China, was first reported based on 783 specimens collected in Biandantang (BDT) Lake, central China from October 2016 to September 2017. The overall sex ratio (female/male) of T. swinhonis was 1.03:1, not significantly different from the expected value 1:1 ($P > 0.05$). Nevertheless, sex ratio varied with seasons: 1.32:1 in the pre-spawning season (March–April), while 0.46:1 in the post-spawning season (July–August). The monthly succession of the average gonadosomatic index (GSI) and percentages of mature individuals indicated that *T. swinhonis* was a spring-summer (April–August) spawner. Further, the bimodal distribution of the size of eggs from one gravid ovary and histological analysis of mature gonads suggested that *T. swinhonis* was a multiple spawner with indeterminate fecundity and high degree of spawning asynchronicity. The sizes (L_{T50}) and ages (A_{50}) at first maturity for females and males were 84.47 and 81.86 mm, and 1.62 and 1.56 years, respectively. The batch fecundity (F_B) of this species varied in a wide range from 2006 to 73592 eggs/fish with a mean value of 26487.15 ± 2675.61 (S.E.) eggs and increased with the increase of gonad weight (W_G), eviscerated weight (W_E), total length (L_T) and age (A). Moreover, the relative fecundity (F_R) varied from 421 to 3608 eggs/g with a mean value of 1525.05 ± 238.17 (S.E.) eggs/g and was not significantly correlated with W_E, L_T and A. Therefore, a preliminary conclusion was draw that *T. swinhonis* in BDT Lake possesses high fecundity and prolonged spawning season, resulting in easy population explosion and probable importance in terms of fisheries management. Thus, the findings presented herein may help the authorities concerned to take effective strategies regarding to fish stock assessment and fisheries management of *T. swinhonis*.

10-O Spatial mismatch between fish and *Microcystis* bloom as revealed by hydroacoustic measurements of both fish and cyanobacteria.

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Microcystis, one of the major components of cyanobacterial blooms, produce microcystins (MCs), which can be toxic to many aquatic organisms, including fish. Due to the climate change and human-accelerated eutrophication, it is expected that the probability for cyanobacterial blooms will increase in the near future. The aim of this study was to investigate the effect of cyanobacteria and their toxicity on fish abundance and distribution. Simultaneous measurements of cyanobacteria and fish distribution were performed in years 2013-2015 in the shallow lowland Sulejów Reservoir along ten predetermined transects. Both fish and cyanobacteria were accessed using Simrad EY60 split beam echosounder pinging horizontally with frequency 200 kHz. Additionally, a phyco-cyanin fluorescence on-line detection method was used to estimate the cyanobacterial biomass. The highest biomass of cyanobacteria was observed in 2015 (33.9 mg/dm^3), in 2013 it was 12.2 mg/dm^3, while in 2014 it was the lowest (practically no bloom conditions). Genetic analyses confirmed presence of toxic *Microcystis* (based on a specific fragment of 16S rRNA gene) including toxigenic genotypes responsible for potential to microcystins production (based on a specyfic fragment of mcyA gene).The highest copy numberof 16S rRNA was detected in 2015 (up to 8.87×10^6), in 2013 the maximum was 3.93×10^6, while in 2014 it was the lowest (up to 1.15×10^5). Also, the assessment ofmicrocystins concentration (HPLC) showed that practically they were not detectable in 2014. In turn, the average fish abundances have shown opposite trend, it was the highest in 2014 (623 ± 322 fishha^{-1}), 230 ± 146 fishha-1 in 2013 and the lowest, 188 ± 88 fishha^{-1} in 2015. Results indicated that the presence of cyanobacterial bloom had negative effects on the abundance of fish. Fish were shown to be clearly avoiding the area of the bloom and the maxima of their biomass mismatched in space.

10-O Restoring fisheries of four major Chinese carps stocking in China's largest floodplain lake after Three Gorges Dam—Is it possible?

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Habitat degradation has resulted in reduced fishery yields in many freshwater ecosystems. In Poyang Lake, the largest floodplain lake in China, decreases in water inputs from Yangtze River since the operation of Three Gorges Dam for hydropower generation in 2003 has drastically shrunk the habitats of fishery species and migratory birds. In response, a sluice is being built to restore Poyang Lake's water level. As the sluice will also block the spawning migration of four

major Chinese carps (black carp *Mylopharyngodon piceus*, grass carp *Ctenopharyngodon idella*, silver carp *Hypophthalmichthys* molitrix, and bighead carp *H. nobilis*), stock enhancement has been proposed as part of this multi-faceted habitat restoration project. In this study, we used an Ecopath with Ecosim modeling approach to simulate simultaneous effects of water-level management, stock enhancement, and fishery policies on the four major Chinese carps. Results showed that while managing water-level, stocking YOY carp, and restricting fisheries all can enhance Chinese carp biomass, restricting fisheries is the most effective. However, even in the best restoration effort scenario (i.e., highest water-level and stocking biomass and no fishing), simulated total biomass of four major Chinese carps was still lower than the 2000 estimates, when natural reproduction was still occurring and fishing intensity was high, suggesting a decline of Poyang Lake's capacity to support fisheries.

10-O Factors Driving Fish Biomass in a Large Eutrophic Lake.

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Our aim was to analyse ecological factors, including interspecific relationships and environmental variables that were related to the dynamics of six fish species biomass in Lake Võrtsjärv, a large shallow eutrophic lake located in Estonia (north-eastern Europe). Possible links between changes in the fish community and those in the environment were investigated using ecological variables annual averages that were collected in situ between 1979 and 2016. To evaluate the most influencing factors we first pre-selected three variables for each fish species using co-inertia, principal component, and random forest analyses. Then, to quantify the variable-predictor relationships we used Generalized Least Squares (GLS) test and generalised linear models on the data subsets, testing both interaction and additive effects. The model outcome revealed that 38% to 56% of the variance of response variables of fish biomass can be explained with descriptive variables which were used in GLS additive models. Indicators of poor water quality (cyanobacteria, cyanobacteria/phytoplankton, and summer temperature) were all negatively correlated to fish biomass. Summer temperature, smaller fish and benthic macroinvertebrate biomass explained 45% of the largest predator biomass. Response of piscivorous fish to benthos and summer temperature was negative while to fish prey biomass and total nitrogen to total phosphorus ratio the response was positive.

10-O Generalist fish inhabiting mesotrophic water bodies accumulate the greatest content of essential long-chain polyunsaturated fatty acids.

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We studied fatty acid composition and contents in conjunction with ratios of stable isotopes of carbon and nitrogen of fish, caught from water bodies of various trophic state, such as roach, Eurasian perch and Northern pike. We tested the hypothesis that 1) trophic state would affect fatty acid and stable isotope trophic markers, as well as contents of long-chain polyunsaturated fatty acids (LC-PUFA) per mass unit of fish; 2) the fish species with a higher trophic position would have greater contents of LC-PUFA. We found the influence of the trophic state of waters on the trophic markers of planktivorous-benthivorous fish, roach, rather than on the markers of omnivorous-piscivorous fish species, like perch and pike. Roach and pike from mesotrophic waters had significantly higher LC-PUFA contents compared to these species from oligotrophic and eutrophic waters. However, content of LC-PUFA in perch biomass didn't vary along trophic

gradient. The second hypothesis wasn't confirmed, i.e., fish of higher trophic position, pike, had lower PUFA contents than fish of lower trophic position, roach. We suggested that mesotrophic waters were the favorable habitat for accumulating the highest content of essential LC-PUFA in fish with various feeding habits, likely due to a cumulative effect of food quantity and quality. These findings may have further implications for commercial catching and management of aquatic ecosystems.

10-O Fish diversity in a Yangtze River floodplain lake (Poyang Lake): dynamics, threats and conservation challenges.

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Poyang Lake, the largest freshwater lake in China, is one of only two lakes still freely connected to the Yangtze River channel. The annual water-level fluctuation averages approximately 12.5 m, and plays an important role in maintaining the unique fish fauna of the Yangtze River floodplain ecosystem. However, loss of fish biodiversity in the lake has been accelerated by a series of direct and indirect effects of human activities and environmental changes. Despite a few publications on ichthyological research in the lake since the 1950s, synthesis and assessment of fish community dynamics, fisheries productivity and major threats are still limited, which in turn limits formulation of conservation strategies. In this study, we conducted a field survey on fish resources and fishery status in Poyang Lake during 2014 and 2016, and compiled and analyzed the scattered data from relevant literature. We documented a total of 136 fish species from 25 families that had been recorded and described in the lake. The fish fauna is characterized by a high proportion of river-lake migratory fish species (e.g. silver carp, grass carp, bighead carp) in the catches, with complex life cycles and ontogenetic shifts between the Yangtze River and Poyang Lake. During the past 60 years, the percentage of small fishes in fish compositions trended to increase, while that of carnivorous fishes trended to decrease and some anadromous and lotic species disappeared. Our assessment on the threatened status of fish species in this floodplain ecosystem indicated that overfishing was the most pervasive threat to the fishes, followed by hydrological flow alterations, lake-to-farmland conversions and industrialization. Development of overfishing control laws, maintenance of the free flow between the lake and the river channel, and explicit collection of life histories information of endangered fish species are highly necessary for successful conservation of the fishes in the compound river-lake ecosystem.

10-O Range expansion and altered dispersal patterns between freshwater lakes facilitated by the East Route of China's South-to-North Water Diversion Project.

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China's South-to-North Water Diversion Project is the world's largest inter-basin water transfer project, diverting water from the Yangtze River to northern regions of China. The east route of this project (ESN, 2013) intersects five large freshwater lakes in Jiangsu and Shandong Provinces: Gaoyou Lake, Hongze Lake, Luoma Lake, Nansi Lake, and Dongping Lake. Artificial connections across drainage divides provide new pathways for dispersal between communities that can often lead to species invasions and range expansions. The freshwater Yangtze grenadier anchovy, *Coilia nasus* (formerly *brachynathus*) has had a range expansion into Dongping Lake in 2013 following operation of the ESd. This species has become one of the dominant species in the lake with multiple size classes observed in 2016, likely indicating local reproduction and

recruitment. A study was done to determine the genetic signature and diversity of this invasive population of C. nasus and determine the most likely genetic source in the water transfer system. Additionally, individuals from the other four lakes were examined to detect other patterns of recent movement along the route. Fifty to one hundred individuals were sampled from each lake and genotyped at 8 microsatellite loci. Approximate Bayesian Computation was used to compare probabilities of invasion models into Dongping Lake from different source lakes along the route. Genetic diversity was compared among the invasive population and the populations in the other four lakes. Genetic assignment tests (Geneclass2) and BayesAss were used to detect individuals in lakes that were likely migrants or offspring of migrants from other lakes to determine general patterns of movement facilitated by water transfer along the ESN. Preliminary results are discussed which provide insight into ongoing community and metapopulation changes following artificially enhanced structural connectivity in this system.

10-O Character of genetic diversity and quality of Chapila in Kaptai Lake of Bangladesh.

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Kaptai Lake is the largest man-made freshwater body in Bangladesh, located in the Kaptai Upazila at Rangamati district of Chittagong. It was created by damming the Karnafuli River for hydroelectric power. This is the only man mad lake in Bangladesh where Chapila (*Gudusia chapra*) and Kechki (*Corica soborna*), both important native species, are dominant and they contribute more than 50% of the total catch in this lake. In order to know if the genetic diversity and quality (microbial and nutritional) result in their dominance in this lake, we compared three different populations of Chapila from Kaptai Lake, Meghna River of Comilla district and the marine respectively. The genetic diversity of Chapila was elucidated using ten RAPD decamer primers (OPA-02, OPA-03, OPA-04, OPA-09, OPAK-04, OPAL-04, OPAW-09, OPF-01, OPG-04 and OPG-05). The microbial and nutritional quality of fish was tested at the same time. Our results were shown as follow:

(1) The population of Chapila from Kaptai Lake showed the higher genetic diversity, compared with populations from other locations. These Chapila populations showed 80.40% of polymorphisms along with highest genetic distance 1.7108 and lowest 1.6463 based on RAPD analysis. The highest genetic identity (0.9880) was found between the Kaptai Lake and Meghna River Chapila populations, which indicated that these two populations are more similar than Chapila marine population. On the other hand, the lowest genetic identity of 0.1807 was observed between Chapila marine and Meghna River, which means they were genetically distant to each other. The cluster analysis segregated the three different Chapila populations into two clusters: Chapila marine located into one major cluster C1 and the rest two Chapila populations in cluster C2.

(2) Three pathogenic bacteria species (*Vibrio, Salmonella Shigella* and *E. coli*) were tested in the Chapila from Kaptai Lake, in order to reveal the health and safety quality of this fish. The microbial count of these fish denoted that the total viable bacterial count was quantified as 4.2×10^5 cfu/g. The total *Vibrio* was found 1.1×10^3 cfu/g, total *Salmonella Shigella* was quantified as 0.9×10^3 cfu/g. No *E.coli* was found in this investigation. Total viable bacterial counts were within the acceptable limit of ICMSF (1986). However, total *Salmonella Shigella*, total *Vibrio* counts were exceeded the limit.

(3) This Chapila fish from Kaptai Lake is nutritionally good enough and good source of energy for human consumption. The nutritional level of wet sample in these fishes were determined by moisture (77.984%), crude fiber (0.022%), crude protein (13.99%), fat (0.491%), ash (3.702%) and carbohydrates (3.81%) and the energy 75.629 Kcal in 100g.

In conclusion, the population of Chapila from Kaptai Lake have the high genetic diversity and nutritional quality, but unhealthy because of the risk of pathogenic bacteria. It's deserved to do more work for conservation in the future research.

10-O Active biomonitoring of metals in representative water-bodies of Jiangsu Province using "standardized" *Anodonta woodiana*.

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"Standardized" freshwater mussels *Anodonta woodiana* were artificially propagated in the Nanquan Aquaculture Base, Chinese Academy of Fishery Sciences, which possessed similar biotic variability, germplasm strains, and low contamination background. The mussels were translocated to 7 representative water-bodies in the Taihu Lake (Lishan Bay and Meiliang Bay), the Gehu Lake (Fanbaoqu and Taipinggang), the Shaobohu Lake (Yanhucun and Manshuiqiao), and the Maifenbang River for 1 month active biomonitoring of metals. Thirteen metals (Al, Cr, Mn, Fe, Ni, Cu, Zn, As, Mo, Cd, Ba, Tl, and Pb) were analyzed by ICP-MS in mussel and water samples from the aforementioned translocated sites and control site of the Nanquan Aquaculture Base. Metal levels in the waters of all sites were generally within the Chinese permissible levels, and all the water-bodies could be categorized into clean level by Nemerow Pollution Indexes (0.11-0.16). Contrastly, Relative Metal Loads of the mussels from the above 7 water-bodies reached to 1.52, 2.43, 2.87, 3.09, 2.38, 1.3, and 1.04, respectively. Metal Residual Index (*I*) of the mussels suggested that Lishan Bay might be lightly contaminated by Al (*I*=0.28) and Pb (*I*=0.26); Meiliang Bay might be lightly contaminated by Pb (*I*=0.31), but heavily contaminated by Al (*I*=1.13); Fanbaoqu and Taipinggang of the Gehu Lake might be lightly contaminated by Al (*I*=0.24, 0.25) and Pb (*I*=0.55, 0.45); Yanhucun of the Shaobohu Lake might be lightly contaminated by Al (*I*=0.34) and Pb (*I*=0.30); and the Manshuiqiao of the Shaobohu Lake (*I*=0.36) and the Maifenbang River (*I*=0.33) might be lightly contaminated by Pb. Meiliang Bay of the Taihu Lake was even listed at lightly pollution level by Average Synthetical Pollution Index. The present study suggests that much more attention should be payed to the dynamics of Al and Pb in lakes and rivers in Jiangsu Province.

10-P Effects of size of gillnets on species composition and size structure of fish: A case study of Dianshan Lake.

Zhangshun

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From 2009 to 2010, a multi-mesh single-layer gillnet was used to investigate the fish community in Dianshan Lake, Shanghai. A total of 28 species of fish were collected in this survey, belonging to 8 orders and 8 families, of which the main species was the *Cypriniformes* .Using CLUSTER clustering, SIMPER similarity analysis method to study the spatial and temporal changes of fish community structure, the different mesh size of the species composition and size structure of the catch, the results showed that: fish community structure in the spatial no difference, However, there are extremely significant differences in time.The six mesh sizes of 2,4,6,8,10,12 cm significantly affected the species composition of the catches and were divided into three groups in total. The catch species of the 2-8 cm net were classified into CX groups, 10 cm nets.For the CY group, the 12cm mesh is classified as the CZ group, and the main differences between the three groups are: and the main differences between the three groups are:CX and CY are *Acheilognathus taenianalis*,*Coilia ectenes*,and *Culter erythropterus*;CY and CZ are *Acheilognathus taenianalis*, carp and silver carp; CX and CZ are carp,*Coilia ectenes*,silver carp and so on.The body length distribution of different mesh catches has certain regularity and range, there is a great difference between 2~10cm and 12cm mesh, and the main differences exist in two body length groups of 10~15cm and 40~45cm. There are some defects in the mesh size in this

experiment, which need to be improved, and reasonable collocation of other nets, to correct the data deviation of single barbed wire, and lay a foundation for future research on fish community in a more scientific way.

10-P Fish community change and fishway usage evaluation after Nakdong estuary barrage construction (1987) in South Korea.

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Physical habitat alteration by the construction of dams, weirs, and estuarine barrages affect the fish community in aquatic ecosystems. Fishways are used to reduce the negative effect on fish community. In South Korea, estuarine barrages were constructed for water supply in three large river ecosystems—Nakdong, Geum, and Yeongsan—during 1980–1990. In the Nakdong estuarine barrage, five fishways (two paddle types and three passage types) were constructed. In this study, we (1) reviewed long-term (32 years) change of fish assemblage in Nakdong estuarine barrage based on the data of K-water and scientific studies conducted by the freshwater Ecology lab of the Pusan National University (2) assessed the efficiency of fishways by reviewing two studies (conducted during Sept 2003–Jun 2005: twice a day, once a week at two fishways; and Sept–Dec 2015: once a month at five fishways) and comparing the fish communities between two sites (above and below the estuarine barrage sites in Nov 2017 and Apr 2018, once a month). Our results showed that the number of fish species has been steadily decreasing over the past 30 years after estuary construction (86 to 26 species). The number of fish species using fishways was 31 in 2005 and 26 in 2015. The dominant species were Barbel steed (*Hemibarbus labeo*) in 2005 and Japanese anchovy (*Engraulis japonicas*) in 2015. Most migratory fish species (i.e., *Mugil cephalus* etc.) were coincidently collected at both the up- and downstream sites. In conclusion, fish communities have steeply decreased after the Nakdong estuarine barrage construction. Nevertheless, fish species richness remain relatively high in the fishway. The government will be considering opening of weir gates (expected during 2018–2019) to restore ecosystems affected by barrage construction. Our results could provide basic information for a restoration plan after opening of the weir gates.

11. Modeling lake and river ecosystems

11-O Modelling of trophic state of New Zealand lakes and visualisation with a novel geospatial platform.

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Layers of georeferenced environmental data are increasingly providing a powerful basis for data analysis, modelling and citizen engagement. We have developed a geospatial platform for visualising New Zealand lake data. It provides a comprehensive repository for data related to morphology, high-frequency sensors, satellites, inflow stream typology, catchment soils, hydrology, meteorology and related literature. Information to support the geospatial platform is sourced at scales ranging from national databases to individual lake-monitoring points. We have used national-scale information on discharge as well as total nitrogen (TN) and total phosphorus

(TP) loads to lakes, to develop in-lake TN and TP mass budget models from which it is possible to empirically derive annual mean chlorophyll a concentrations. We have calculated TN, TP and chlorophyll a concentrations for >800 lakes of area >2 ha. Multiple mass-budget and nutrient−chlorophyll a models are used to generate a range of output concentrations and provide a basis for considering uncertainty in predictions. The model outputs are being viewed against the National Objectives Framework of the New Zealand National Policy Statement for Freshwater Management. The geospatial platform provides a valuable tool to be able to visualise water quality at scales ranging from an individual lake to the whole of New Zealand, and to assess trophic state of lakes against designated national standards.

11-O Evaluation of River Ecosystem Health based on Hydrophytes in the Upper Han River: A Case Study of 5 Tributaries. *Fu Wenlong*

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Based on the seasonal vegetational survey, plant functional traits and environmental factors, the species composition, plant community diversity and plant functional traits of five tributaries of the upper Han River (Jinshui River (JSH), Yue River (YH), Jinqian (JQH), Si River (SH) & Qi River (QH)) were investigated. Variance analysis, correlation analysis among other multivariant analysis were used to sift five candidate indicators: species number, mean multiplicity, number of invasive species, species number during flowering and number of species in the resultant period from prepared 20 indicators and the IBI index constructed using the six candidate indicators. The sum of healthy and sub-healthy sites was used as the evaluation criteria. The result showed that IBI index:81.25% (JSH) > 80% (YH) > 76.92% (QH) > 70% (SH) > 56.25% (JQH). The healthiest river was the JSH and the least healthy was JQH. These results are consistent with environmental factors, the number and diversity of hydrophyte species and other parameters.

11-O Modeling ecosystem structure and function in both temperate and sub-tropical shallow lakes using PCLake. *Xiangzhen Kong[1], Fuliu Xu[2], Jan Kuiper[3], Wolf Mooij[4, 5], Karsten Rinke[1]*

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Shallow lake ecosystems provide critical ecological services to human being and are however subject to severe perturbations from anthropogenic actives. Temperate and sub-tropical shallow lakes show distinct features in terms of ecosystem structure. However, influential factors, underlying mechanisms and consequences on the ecosystem function of these differences remain unclear. This knowledge gap has hampered the application of the successful experiences for shallow lake restoration in e.g. European countries to other regions such as China. Using an integrated aquatic ecosystem modelling approach, we aim to unravel the consequences and drivers of these differences in ecosystem structure. We found that the dominance of omnivorous fish is the key player in determining the truncated structure of food webs in sub-tropical shallow lakes, which is approximately one trophic level shorter than the triangular food web structure observed in many temperate shallow lakes. In addition, the model simulation suggests that the trophic interaction could be more vulnerable in sub-tropical than temperate shallow lakes. The model

further indicates that the net production in subtropical lakes is higher than that in temperate ones, but the efficiency in energy utilization is lower. Our comparative limnologic approach may provide insights in understanding shallow lake ecosystems, e.g. how ecosystem structure is connected to biodiversity and function. The findings may contribute to the pursuit of the proper restoration strategy in sub-tropical eutrophic shallow lakes, and facilitate the prognoses of shallow lakes for the future in the context of global change.

11-O A Modified QWASI Model for Fate and Transport Modeling of Copper Between Water and Sediment in Lake Ulansuhai.

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A field experiment about the flux of sediment re-suspension and deposition was carried out in Ulansuhai to improve the QWASI model, which was used to model the transport processes in both the water and sediment during the unfrozen period. The results shown that the net transport direction of Cu was from the water to sediment with a total amount of 5317kg. During this processes, the fluxes of sediment re-suspension and deposition ranged from 4.37g/$m^2 \cdot d^{-1}$-54.5 $m^2 \cdot d^{-1}$ and 9.1 $m^2 \cdot d^{-1}$1-101.4 $m^2 \cdot d^{-1}$, respectively. There was a significant positive correlation between the re-suspension and sedimentation fluxes and the wind speed. The margin of error between the modelled and measured Cu concentrations in water and sediment were 13.2%-26.8% and 5.1%-12.8% respectively, meaning that the improved model could better describe the re-suspension and sedimentation processes of the sediments and the transport processes of Cu adsorbed on the solid particles. The amount of Cu transported to the water and sediment were 47930kg and 41261kg respectively through the re-suspension and sedimentation processes. The amount of Cu entered the lake through the inflow water and atmosphere deposition were 3261kg and 2510kg respectively. This indicated that Cu concentration in the water was mainly affected by the re-suspension and sedimentation processes. Sensitivity analysis also shown that the re-suspension and sedimentation fluxes had a greater impact on the model results compared to the sediment burial flux and the MTC between the water and sediment.

11-O The Application of Remote Sensing Inversion via NDWI Index: exploring the changes of area and water salinity in the Ebinur Lake past 40 years.

Yu Peng

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The Ebinur Lake Watershed is located at 43° 38′ -45° 52′ N and 79° 53′ -85° 02′ E in northwest Xinjiang Uygur Autonomous Region of the People's Republic of China. Due to climate change and human activities, serious ecological environmental problems occurred in this area in the past 40 years. Studies on the lake area and lake electrical conductivity characteristics changes showed significant influence on the changes of water and arid area oasis ecology environment.

The traditional method of monitoring water salinity is not only labor intensive, but also costly, and it is difficult to conduct a comprehensive, accurate monitoring and evaluation through long time. Besides, observing the long time series changes of lake area using earth observation data from space requires processing of large amount of satellite images acquired by various sensors, which takes a lot of time. A new and simple method is expected to help these works.

In this research, we tested physicochemical characteristics with surface water samples collected from the Ebinur Lake in 2017. Meanwhile we used Google Earth Engine platform to extract normalized difference water index (NDWI) from Landsat images in the same period and to analyze the correlation of NDWI and water salinity. The Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, CO_3^{2-}, HCO^{3-}, SO_4^{2-} and Cl^{-} were tested after the water sample was brought back to the laboratory. The NDWI can

make use of reflected near-infrared radiation and visible green light to enhance the presence of such features while eliminating the presence of soil and terrestrial vegetation features and also provide turbidity estimations of water bodies using remotely-sensed digital data. We use the band math tool provided by Google Earth Engineto calculate different bands to get the NDWI value. Based on the curve fitting analysis of SPSS software, a good correlation model was found between NDWI and physicochemical characteristics. The correlation model founded is cubic function and their relationship model can be expressed as Y=AX+BX+CX+D, where A, B and C are all coefficients of X, and D is constant. The research result has verified obvious correlation between NDWI and chemical characteristics of the Surface Water and the Correlation Coefficient is over 0.75.

This means that remote sensing can provide an effective method for long time series and low-cost water salinity detection. So we apply remote sense inversion in the Ebinur Lake via NDWI index, exploring the changes of area and water salinity in nearly 40 years.

The Google Earth Engine is an online environmental data monitoring platform that incorporates data from the National Aeronautics and Space Administration (NASA) as well as the Landsat Program. Google uses its cloud computing resources to allow records of Landsat images to be accessed and processed over its online system. This has enabled users to reduce processing times in analyses of Landsat imagery and make global scale or long time series Landsat projects more feasible. We used GEE to produce the serial Landsat images from 1984-2018 and identified the annual lake border by extracting NDWI index. Basing on the cubic function verified, the annual water salinity parameters can be calculated by NDWI. In this way, the lake area and water salinity changes can be obtained through the inversion of NDWI. The results show that the changes of water salinity and the lake area have changed obviously over the past 40 years, which is consistent with some known prior data and the pattern of change.

The changes of characteristics and area in the Ebinur Lake are of great significance to the sustainable utilization of water resources and the sustainable development of social economy. Inversing the lake area and water salinity changes via NDWI greatly contributes to the application of the ecosystem service approach in research. Besides, it provides some scientific basis for the application of remote sensing technology to the extraction of surface water salinity. It not only verified the correlation between NDWI and chemical characteristics, which provides a possibility for the low-costly method to monitor long time series changes of water salinity by remote sensing inversion, but also provided the experimental experiences for rapidly processing massive remote sensing images by web platform and its applicability in arid area.

11-O Parameter uncertainty and sensitivity analysis of water quality models in lake ecosystems.

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Lake Taihu was chosen as a case for parameter uncertainty and sensitivity analysis of water quality simulation in large shallow lakes. Forty parameters in Environmental Fluid Dynamic Code model (EFDC) were filtered and analyzed. The results showed that parameters had a considerable influence on simulation and three groups of parameters related to algal kinetics (i.e. PMc, BMRc and PRRc), light (KeChl) and temperature (KTG1c) were very sensitive. For shallow lakes with frequent algal blooms, light extinction due to Chlorophyll-a is also a sensitive parameter. While the temperature effect coefficient for algal growth is sensitive for lakes with seasonal temperature variation. Sensitive parameters and their relevant uncertainty varied spatially. For high nutrients and algae concentration subareas, temperature was more likely to be a limiting factor, whereas sensitive factors could be light in lower concentration subareas. Since most sensitive parameters were related to algae, uncertainty in simulation increased with increasing algal kinetic processes over time and varied in different subareas. Lower nutrients and algae concentration subareas were more easily influenced by model parameters while nearshore areas were highly influenced by boundary conditions. For better simulation of water quality, variable stoichiometry phytoplankton

models should be considered and zooplankton need to be integrated into the model explicitly rather than a fixed predation rate.

11-O Taking advantage of model diversity: benefits of ensemble modelling for managing algal blooms in polluted lakes.

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Climate change and increasing anthropogenic stress have intensified the occurrence of nuisance algal blooms worldwide. Toxic and highly adaptive blooms of cyanobacteria can threaten drinking water safety and break down ecosystem functions by suppressing aquatic macrophytes. To prevent the deterioration of aquatic ecosystems, ecological models play an important role to simulate possible scenarios and provide options for environmental management. However, the complexity of ecosystems makes it difficult to simulate all the physical, chemical and biological processes in one model. Instead of looking for a panacea, the urgent demand for such management tools has accelerated the development of a large and diverse number of ecological models for different contexts. Ensemble modelling is an approach inspired by weather forecasting. Model diversity is exploited to improve the robustness of algal bloom prediction. Ensemble modelling might also result in important insights how the differences in model structure contribute to the fit of the models to data.

In this study, we selected two ecological models to examine their underlying causality. One widely applied model is PCLake, which is a dynamic model and includes food web interactions. PCLake is often used for so-called bifurcation analysis to define the critical loading that define lake regime shifts. Another widely applied model is BLOOM, whose phytoplankton module is built with linear programming and supported by an empirical database. To see how the models' conceptual differences reflect on the simulated outcomes, we analyze their differences in model structure and thereafter run them for theoretical scenarios that vary in temperature, nutrient loading and light intensity， respectively. As a final step, we plan to apply both models in real-world scenarios and validate them with observed data, to see and explain how ensemble modelling works in practice. Our results show that ensemble modelling can be beneficial for managing algal blooms in polluted lakes.

11-O The Ecospace model as a simulation tool for spatial planning scenarios of fish biomass in a large shallow lake.

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We wanted to examine the combined effects of climate change and human activities (fishing fleets and gear) on the fish biomass distribution in a large shallow eutrophic lake located in Estonia (northeastern Europe) using Ecospace model (Ecopath with Ecosim modelling suite). We simulated and analyzed the spatiotemporal model results for 37 years of data consisting in 19 functional group including 3 multi-stanza (larvae, juvenile & adult) for predator fishes (pike and pikeperch), also including two fishing fleets. The results showed that the spatial distribution of fish biomass was very uneven in the lake, with the southern province exhibiting a greater fish

concentration than all other regions combined. The density of macrophytes and inaccessibility to fishing fleet were the main cause for such discrepancies. We also introduced spatial scenarios based on one-meter lake water level rise or decrease for predicting changes in species population density, distribution and fishery pattern. The 1m decrease scenario caused a diminution in surface area as well as in biomass of several species including the phytoplankton and fishes. With respect to control, the fishing pattern clustered in a few specific areas and was reduced overall. In 1m increase scenario caused a weak decrease in all the species biomass whereas the fishing effort is similar to the control model. The simulation of these scenarios would be effective tools for future spatial management regulation where fishing resources ought to be protected.

11-O Three possible futures: response of lake cyanobacteria and zooplankton to climate change.

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We constructed a model chain into which regional climate-related variables (air temperature, precipitation) and a lake main tributary hydrological indicators (river flow, dissolved inorganic carbon) were employed for predicting the evolution of planktonic blue-green algae (cyanobacteria) and zooplankton (rotifer) biomass in that lake for the mid-21st century. Simulations were based on the future climate predicted under both the Representative Concentration Pathways 4.5 and 8.5 scenarios which, combined with three realistic policy-making and basin land-use evolution lead to six scenarios for future water quality. Model outputs revealed that mean annual river flow is expected to decline between 3 to 20%, depending of the scenario. Concentration of river dissolved inorganic carbon is predicted to follow the opposite trend and might soar up to twice the 2005-2014 average concentration. Lake planktonic primary producers will display quantitative changes in the future decades whereas zooplankters will not. A 2 to 10% increase in mean cyanobacteria biomass is accompanied by a stagnation (-3 to +2%) of rotifer biomass. Changes in cyanobacteria and rotifer phenology are expected: a surge of cyanobacteria biomass in winter and a shortening of the rotifer biomass spring peak. The expected quantitative changes on the biota were magnified in those scenarios where forested area conversion to cropland and water abstraction were the greatest.

11-O Impacts of tide and fronts on ecosystem in the North Sea.

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As the dominant feature in the hydrodynamics of the North Sea, tidal forcing regulates the mixing-stratification status and hence influences the whole ecosystem. Here we highlight the importance of tides for controlling the hydrodynamic features and hence influencing distribution of primary production and other ecosystem components on different spatial and temporal scales. Particularly we investigate tidal impacts on net primary production (NPP) and the relationship between tidal fronts and ecosystem dynamics by using the well validated 3D physical-biogeochemical coupled model ECOSMO, combined with satellite image and fish egg/larvae data measured on cruise. First, by turning on and off the tidal forcing, the simulation results indicate a reduced NPP in southern shallow areas due to the mixing diluted phytoplankton concentration in the upper layer and tidal induced turbidity. In contrast, in the seasonal stratified areas, tidal forcing causes additional nutrient injections to the upper mixed layer, which releases nutrient limitation and hence sustains PP during seasonal stratification. Shifting of the onset of the spring bloom is analyzed in terms of the variation of stratification, light condition and grazing pressure. The mechanism that stirred up nutrients pumped by tidal mixing further sustain the NPP

of subsurface biomass maximum layers is also investigated. Second, we prove that the recurrent tidal fronts simulated by ECOSMO corroborate well with those detected from satellite data. Spawning locations of fish (cod, plaice) are spatially associated with fronts system. By utilizing the simulation, we further investigate related characteristics of fronts such as current convergence, periodically mixing, nutrients enrichment and advection, to explain the bio-rich phenomena. The inter-annual variability of the fronts and the related impacts on the ecosystem are also explored.

11-P Assessment of a small lake trophic state in response to nutrient loading changes.

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Most of the lakes in European Russia are significantly affected by pollution. In Moscow Region, only a handful of lakes remain in their natural state, and their number is constantly further decreasing. In those circumstances, it is important to understand the consequences of increasing pressure on aquatic ecosystems, particularly nutrient loading.

Lake Glubokoe, a small mesotrophic lake in Moscow Region, Russia, was targeted as a subject for this research. Lake has no inlets and isn't affected by human activity, allowing to suggest that the lake's natural state is not altered. One-dimensional MyLake model was used to calculate annual dynamics of vertical distributions of water temperature, chlorophyll, and mineral phosphorus concentrations. Data from Mozhaysk weather station was used for meteorological input. The model was calibrated on extensive field data from 2017 and evaluated on less frequent monitoring data from 1991–2015. Model validation showed a good convergence of model output and observations after calibration.

The possible consequences of increasing phosphate loading into the lake were studied by conducting several model scenarios calculations. Phosphate concentrations for different scenarios were set according to Russian standards. These regulations allow different phosphate concentrations in wastewater runoff depending on receiving lake's trophic state. Wastewater discharge was also varied in different scenarios.

Simulation results show the trophic state of Glubokoe Lake to be shifting to eutrophic even when phosphate concentration in wastewater is within the limits set for mesotrophic lakes. If phosphate concentration in wastewater is set according to regulations for eutrophic lakes, the effect of phosphate loading becomes devastating, leading to rapid degradation of the lake ecosystem. It is also shown that phosphate concentration plays a more critical role than wastewater discharge.

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12. Paleolimnology and long-term changes in aquatic ecosystems

12-O Paleolimnology meets conservation biology: Developing tools to track long-term dynamics in bird populations.

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Nutrient and contaminant fluxes across ecosystem boundaries via biovectors (such as

seabirds, which feed in the ocean, but then nest on land) can exert strong direct and indirect effects on the dynamics of inland waters and surrounding catchments, especially in nutrient-poor environments. The limnological consequences of these processes (e.g., guano fertilization of nearby ponds) can be exploited by paleolimnologists to track long-term dynamics in ecosystems affected by these biovectors. For example, the conservation of seabird and waterbird species that are believed to be at risk is difficult due to a lack of long-term population surveys, therefore it is challenging to determine population dynamics prior to direct observational changes, which are notoriously short term. Here we summarize recent paleo-ornithological studies using shallow lake sediments to track avian populations. For example, a vulnerable seabird species is the Leach's Storm-petrel, which has been declining globally in recent years. Due to their small stature and nocturnal behaviour, Storm-petrels are difficult to survey accurately, and thus fluctuations in colony size and the processes driving colonial trends remain unclear. Prior to fledging, Storm-petrel chicks remain in their nests acting as nutrient biovectors, fertilizing the nearby water bodies with their nutrient-rich guano, moulted feathers, and carcasses. This fertilization causes changes in the ponds' water chemistry variables and aquatic biota, leaving distinct geochemical and biological signatures in the sediments. Similarly, long-term population data for waterbird species in the Great Lakes of North America are sparse, with most censuses having taken place in the last 30-40 years. Sediments from shallow ponds on summer nesting islands in eastern Lake Ontario provided a unique archive to extend census data by tracking the arrival and population shifts of waterbirds, as well as their associated ecological impacts. Development of new "fingerprinting" geochemical techniques potentially allows for further refinement of long-term ecosystem dynamics in these exploratory studies.

Environmental archives provide valuable chronologies of trace metal loadings on terrestrial and aquatic ecosystems throughout the Holocene and beyond. Our study focuses on three mountain watersheds located in the central Pyrenees and on specific trace metals: Pb, Cu, Sb, and Hg recorded in environmental archives. Whereas Sphagnum peatlands provide ideal past records of atmospheric deposition, lake sediments illustrate chemical loads from the entire watersheds. We will discuss the differences between the archives and the time periods and we will show how a landscape approach can help to understand the impact of early industrialisation. We will show that if long-term transport of trace metals could have occurred in preindustrial periods, a large part of trace metal contamination may be due to local metallurgical activities and further remobilization due to soil and vegetation degradation. We will show how the comparison between peat and lake archives can be used to investigate stability, disturbances and the resilience of mountain watersheds.

12-O Water quality deterioration in lakes of the middle Yangtze Basin since the 1980s.

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Intensification of human activities and associated pollutant transport into freshwater bodies have resulted in the deterioration of lake ecosystems. The middle and lower reaches of the Yangtze Basin, inhabited by more than 300 million people, is one of the most developed areas in China. Over the last several decades, lakes in this area have suffered from problems such as eutrophication and declines in biodiversity due to strong human perturbations. In addition, hydrology is a key factor controlling ecosystem wellbeing of floodplain lakes. Because long-term monitoring of these lakes is lacking, we used paleo-limnology to understand the extent and consequences of the rapid intensification of human impacts. Analysis of chlorophyll and carotenoid pigments and chironomid remains in dated sediment cores allowed us to track ecological changes in the lakes. Hydrological stabilization caused by local dam construction increased the growth of aquatic plants (indicated by macrophyte-related chironomid). However, over-riding this trend, pigments in cores from six lakes spanning this region showed a sharp breakpoint around the 1980s consistent with an increase in primary producers, including potentially bloom-forming cyanobacteria. This change coincides with the major period of rapid

development in the region when nutrient loading increased due to agricultural and industrial development and urban expansion. The changes recorded by our sediment cores record an unambiguous and widespread decline in water quality across the middle Yangtze Basin lakes, which probably increased the size and frequency of cyanobacterial blooms around 35 years ago.

12-O Strong ecological and environmental changes related to water level fluctuation and anthropogenic pressure in large shallow Lake Liangzi in the Yangtze floodplain, China since the mid-19th century.

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Macrophyte composition and abundance can affect the overall ecological structure and function of shallow lakes: information of the nature and timing of such changes is, therefore, crucial for understanding the impact on the wider lake ecosystem. Here, we examined plant macrofossils, along with diatoms and cladocerans as well as physical and geochemical proxies from two sediment cores from Lake Liangzi, a large shallow lake located on the Yangtze floodplain in SE China, in order to assess trajectories of ecological and environmental change. Based on the palaeolimnological and documentary records, redundancy analysis identified the drivers potentially affecting ecological and environmental dynamics. Results indicated that hydrology and anthropogenic pollutant inputs were the main drivers of ecological and environmental changes in the lake. Ecological change, resulting from water level fluctuations and anthropogenic pressure, was shown to have occurred with a shift from a clear water, low-growing submerged macrophyte community (e.g. Najas minor, charophyte species), dominated by planktonic diatoms and planktonic cladocerans towards a pollutant-resistant, tall-growing macrophyte community (*Potamogeton* spp., *Ceratophyllum demersum* and *Myriophyllum spicatum*) with dominance by benthic and epiphytic diatoms and littoral cladocerans during the past ~160 years. However, a pronounced increase in the abundance of planktonic Bosmina spp. at the expense of a decrease in littoral species and the decline or disappearance in macrophyte abundance in the surface samples suggest that Lake Liangzi recently entered into another unprecedented state. Our study demonstrated that plant macrofossils of radionuclide-dated short sediment cores provide reliable information on the nature and timing of changes in the macrophyte community in Yangtze shallow lakes. Furthermore, our study provided information on composition of the plant community before strong recent perturbations and the trajectories and drivers of ecological and environmental change, thus offering valuable information for lake managers.

12-O Trace metal legacy on mountains aquatic ecogeochemistry (TRAM).

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Due to their geological features, mountain environments have been exploited since the beginning of metallurgy. The Pyrenees are no exception as many mining sites in the region have been dated back to the Bronze Age resulting in a potential human impact on the environment on millennial scales. The mountain landscape is sensitive both to human-induced environmental changes - e.g. agriculture, mining, clear cutting- and climate-induced rapid environmental fluctuations. The legacy of trace metals stocked within the mountain watersheds is poorly understood. Pyrenees provide a perfect mountain range for detailed scientific investigations on the fate and impact of anthropogenic potentially harmful trace elements on the ecological functioning of mountain catchments, including high altitude lakes.

Environmental archives provide valuable chronologies of trace metal loadings on terrestrial and aquatic ecosystems throughout the Holocene and beyond. Our study focuses on three mountain watersheds located in the central Pyrenees and on specific trace metals: Pb, Cu, Sb, Hg recorded in environmental archives. Whereas Sphagnum peatlands provide ideal past records of atmospheric deposition, lake sediments illustrate chemical loads from the entire watersheds. We will discuss the differences between the archives and the time periods and we will show how a landscape approach can help to understand the impact of early industrialisation. We will show that if long-term transport of trace metals could have occurred in preindustrial periods, a large part of trace metal contamination may be due to local metallurgical activities and further remobilization due to soil and vegetation degradation. We will show how the comparison between peat and lake archives can be used to investigate stability, disturbances and the resilience of mountain watersheds.

12-O Hierarchical response to nutrient enrichment among different biological communities in shallow Yangtze lakes.

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In this study, we analyse the cumulative rate of compositional change along a nutrient gradient in the 90 shallow lakes from the middle and lower reaches of Yangtze River for three different groups of aquatic organisms – Cladocera, chironomids, and diatoms. In particular, we are interested in the magnitude of unusually large changes in species composition that allows the detection of significant structural change for each of these three organism groups. Ordination analysis revealed the nutrient (total phosphorus) are the most important factors regulating all the biota groups, explaining the species variance of 4.2%, 8.2%, 11.5%, respectively. An approach combining Structurechange & Breakpoint F-test revealed the threshold of significant community changes along TP gradient for Cladocera, chironomids, and diatoms is 95 (with macrophyte), 108 and 90 ug/L, respectively. We also examined the response patterns of the three biological groups to nutrient enrichment in a short sediment core, a record for the past 150 years from Taibai Lake. We concluded that: 1) Primary producers in the ecosystem/foodweb are much sensitive to nutrient enrichment; 2) 80-120 μg/L can be set as TP threshold for significant ecological change in Yangtze

lakes; 3) Significant discrepancy on the time and rate of shifts was found among different organisms, reflects the intrinsic ecological process may vary due to the different resilience and ecological mechanisms. Hence, there are considerable differences among the three organism groups, suggesting that different environmental factors may influence the rates of compositional change within and among groups.

12-O Reconstructed Water Area of Lop Sea during 13th – 15th Century.

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Lop Sea (or Lop Nor, Lop Nur), a vast playa currently covered with salt crust locating in the east of Tarim Basin, was used to be the terminal lake of Tarim River until its desiccation last century. It was located at the overlap of Westerly and Asia monsoon thus sensitive to climate change. However, the exact location and boundary of the lake and whether it had dried up ever before in historical period was on debate for decades. The geomorphology trace might remain as the evidence of fluvial migration for long time due to the extremely arid climate in the uninhabited Lop region. While the topographic features were usually minute in elevation difference (< 1 m) and spatial size (several meters), which required Digital Elevation Model (DEM) in high accuracy beyond all the published data set. In this paper, DEM with 10-meter spatial resolution and vertical precision better than 1 meter, was derived from TanDEM-X/TerraSAR-X data by interferometry method, and verified by both ICESat-GLAS laser footprints and local DEM measured by unmanned aerial vehicle. Loulan depression, a region in the west of Lop Sea discovered and nominated by Hedin at 1901, was verified for the first time in DEM, whose existing time, 1260-1450 AD, could be inferred by previously published radiocarbon dating of floral debris both along its main tributaries and on stratum of Lop Sea. The stratigraphic evidence of Lop Sea also indicated Tarim River did not feed Lop Sea between 1500-1900 AD, when Lop Sea must be desiccated. Obviously both the interpretation and age-depth model of sedimental samples in Lop Sea should be re-estimated. The method to produce reliable high-accuracy DEM could also be applied to other inland lakes or rivers in arid region to expand the insight of their history.

12-O Long-term succession of aquatic plants reconstructed from palynological records in a shallow freshwater lake, China.

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Aquatic plants in shallow freshwater lakes play a key role in stabilizing ecological function and providing valuable ecosystem services, yet they are under severe degradation worldwide. An improved understanding of long-term aquatic plant succession is critical to investigate the potential driving mechanisms and to facilitate ecological restoration. In this paper, we reconstructed changes in the aquatic plant community over the past century based on palynological records from Changdang Lake, Middle and Lower Yangtze River (MLY) Basin, China. Our results reveal that aquatic plants in Changdang Lake have undergone three clear phases: emergent macrophytes dominated in ca.1900s-1970s, submerged macrophytes dominated in ca.1970s-1990s, and floating macrophytes increasingly dominated after the 1990s. Increasing multiple anthropogenic pressures, such as the hydrological regulation oriented damming and the

massive nutrients loading caused by accelerated agriculture, aquaculture, and urbanization after the Chinese economic reform, have caused this significant change by altering hydrological conditions and accumulating nutrients. We argue that Changdang Lake is currently in a transition phase between a macrophyte-dominated and an algae-dominated state. Our palynological records are not consistent with many contemporary studies, which suggest submerged plants were dominant before the 1950s in most lakes across this region. We suggest that the return of the aquatic plants to their 1970s-1980s state would be a realistic target for lake restoration. Our results demonstrate the great potential of palynological records for revealing the long-term dynamics of macrophytes in shallow lakes for sustainable lake restoration and management. Environmental archives provide valuable chronologies of trace metal loadings on terrestrial and aquatic ecosystems throughout the Holocene and beyond. Our study focuses on three mountain watersheds located in the central Pyrenees and on specific trace metals: Pb, Cu, Sb, Hg recorded in environmental archives. Whereas Sphagnum peatlands provide ideal past records of atmospheric deposition, lake sediments illustrate chemical loads from the entire watersheds. We will discuss the differences between the archives and the time periods and we will show how a landscape approach can help to understand the impact of early industrialisation. We will show that if long-term transport of trace metals could have occurred in preindustrial periods, a large part of trace metal contamination may be due to local metallurgical activities and further remobilization due to soil and vegetation degradation. We will show how the comparison between peat and lake archives can be used to investigate stability, disturbances and the resilience of mountain watersheds.

12-O Research on Biochemical Indexes and Their Environmental Significance in the Eutrophic Lake Sediments－ A case study in Tai Hu.

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Eutrophication of lakes is one of the most serious lake environment problems in China. Especially in the developed area and cities of the middle and lower Yangtze River, eutrophication of water body has become the "bottleneck" of regional social and economic development. Tai Hu is the third largest freshwater lake of China, the pollution and eutrophication of water body is very severe. research on DNA can be as a good index for indicating organism and lake environment situation. Based on the research on biological index-fossil pigments and biomacromolecule-DNA, the nutrients evolution and the regional human activities in the Taihu Lake basin had been discussed.

Taking lake sediment cores from the heavy pollution areas in Mei Liang bay and Zhu Shan bay, the vertical distribution of nutrient of sediment cores were investigated using chemical method. The spectral photometer and High Performance Liquid Chromatography(HPLC) were adopted to analyze pigments in the sediment cores, such as chlorophyll and carotene. Molecular biology method was applied to extract DNA of lake sediments from Mei Liang bay and Zhu Shan bay, and the distribution characteristics and the change of content of Microcystin, as well as microorganism population of lake sediments in Mei Liang bay were explored. The results are shown as follows:

(1) As for lake sediments from Mei Liang bay and Zhu Shan bay of Tai Hu, the change trend of total organic carbon and total nitrogen content are basically coincided over the last several tens years, but the change of total phosphorous is little different. Considered the upper 6cm part of sediments from Mei Liang bay, and the top 9cm part of sediments from Zhu Shan bay in Tai Hu, the content of nutrient increases rapidly.

(2) The change trend of various fossil pigments content of Mei Liang bay in Tai Hu is basically increased from the top 6cm part, which indicate that the amounts of lake living things increases largely. The quantity and types of lake pigments could be explained that the organic matter primarily originates from the endogene. The change of Chlorophyll in the sedimentary cores of Mei Liang bay indicates the living things amount increasing.

(3) PCR amplification of Microcystin in sediments from Mei Liang bay and Zhu Shan bay in

Tai Hu shows that the brightness is different in different layer, which reveals the content of Microcystin is different. This is related with eutrophication degree in different period. The content of Microcystin in the upper 6cm part of sediments cores from Mei Liang bay is high, which is related with the outbreak of cyanobacteria during the lake eutrophication period since mid-1980s. Microcystin gene fragment can be amplified from the upper 23 cm part of sediments cores from Mei Liang bay, which is related with the increase of nutrition concentration and Microcystin quantity of water body generated by the development of national industry of Wu Xi area since 1930s --1940s of 20th centuries. The total brightness of PCR amplification products from sediment cores of Zhu Shan bay is lower than that of Mei Liang bay, that is, the content of Microcystin of the former is lower than the latter. On the basis methods of DNA extraction, the conventional SDS-CTAB method was improved. DNA extraction from lake sediments of Mei Liang bay and Zhu Shan bay in Tai Hu was implemented. The distribution feature of DNA, as well as the relationship between DNA and the content of nutrients was analyzed. The results show that the major part of DNA extracted from lake sediments is microorganism DNA, and the content of DNA is higher in the upper part of sediments, indicated positive correlation with the content of nutrients, but the content of DNA in the lower part of sediments is comparatively milder and changing smoothly,

12-O Effects of changes in catchment vegetation and land-use on phosphorous species and primary producers in a small Danish lake during the Holocene.

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This study aims to link long-term changes in catchment vegetation and land-use with changes in sedimentary phosphorus (P) species and response of primary producers in a small Danish lake. We investigated pollen, P pools (sequential P extraction), biogenic P forms (^{31}P NMR), primary producers (diatoms, chlorophyll and carotenoid pigments), stable nitrogen (δ^{15}N) isotopes and plant macrofossils in a ^{14}C-dated sediment record spanning the Holocene. Initially, predominantly minerogenic P forms (Ca bound) were washed into the lake from the bare soils. Then, after the development of vegetation and soils, accumulation rates (ARs) of Fe- and Al-bound P forms as well as organic P, humic acid associated P and refractory organic P gradually increased. Sporadic occurrence of purple sulphur bacteria (highest abundances in the oldest/deepest sediment layers) suggest anoxic conditions. Chlorophytes and cyanobacteria were common throughout the entire profile and diatom assemblages were dominated by eutrophic species, suggesting nutrient-rich conditions even from the beginning of the lake's development. Allochthonous inputs increased with the introduction (~ 3,800 BC) and the intensification (~ 1,000 BC) of farming, mainly animal husbandry, and this boosted the lake's planktonic productivity (indicated by increased δ^{15}N values). Biogenic P forms (neo-IP_6, DNA and phospholipids) are preserved in the sediments as old as ~ 2,500 years. Forest regrowth between AD 200 and AD 1,000 clearly reduced external input and productivity. A drastic change occurred when the wheel plough was introduced and when the lake was used for hemp (*Cannabis sativa*) and flax (*Linum usitatissimum*) retting. High productivity in the lake led to unprecedented high burial of organic material in the sediments. All P forms, including monoesters, showed maximum ARs during the retting period. The preservation of biogenic P forms in such old and deep sediment layers has never been shown before and raises questions about their long-term storage capability.

12-O Anthropocene environmental pollution history derived from peatlands geochemical records in northeast China.

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China has been one of the fast-growing economics of the late 20th and early 21st centuries, and atmospheric metal emissions have been increasing in parallel with rapid industrialization and urbanization, which has led to elevated environmental pollution. Given a growing concern for human health, the historical variation of metal contamination is still not well understood due to the lack of long-term environmental records. Peat records of past environmental changes are still sparse but there are definite advances in the reconstruction of trace metal pollution in China. We review the peat records that detail the history of atmospheric metal pollution over the last two centuries in NE China. The ecological risk (ER) of accumulated metals and their potential eco-toxicological effects, through threshold and probable effect concentrations (TEC and PEC), are also evaluated. Peat records of metals show an increase of pollution loads in the environment over the pre-industrial level during the past two centuries, with an unprecedented increase in China over the last 60 years. There is generally good agreement between geochemical peat records from NE China and others records elsewhere in China. However, some discrepancies are observed especially with Hg records from lake sediments. These discrepancies could be resulted from post-depositional processes or uncertainties arising from dating methods. The ecological risk of heavy metals is found to be relatively weak in the remote and high-altitude environment in NE China. Although, most metals are under the TEC, Pb concentrations usually surpass it and are getting close to the PEC which indicates increasing ecological risks. Some areas of improvement have been highlighted such as the need for more long-term studies on atmospheric metals and a greater number of Pb isotopes records to better capture the long history of human activity and the spatial variability in metal deposition of the region.

12-O 200 years of anthropogenic and climate-driven environmental change in the Songnen Plain, NE China: pollen, human occupation and land use.

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Sediment cores from three lakes in the Songnen Plain provide multi-proxy records of natural and anthropogenic environmental change over the past 200 years in northeastern (NE) China. Analysis of high-resolution pollen (av. 6 yr), particle size, loss on ignition and C/N ratios produced the first records of vegetation history and catchment dynamics in the region. Our records show terrestrial vegetation initially responded to cooler and drier temperatures during the Little Ice Age with high values of *Pinus*, *Ephedra* and *Amaranthaceae* and low values of the aquatic Cyperaceae. Pinus declined from 1850 AD, likely recording increased anthropogenic activity in NE China. Land policy implementation impacted the terrestrial and aquatic vegetation in NE China, with arboreal taxa declining from 1940 AD as marginal land types were reclaimed and agricultural activities increased. Vegetation diversity increased as environmental disturbance

supported a higher number of plant taxa including *Humulus*, *Polygonum* and *Xanthium*. Sand and organic content increased and C/N ratios declined after 1940 AD as erosion in the catchment and productivity in the lakes increased. Aquatic vegetation including *Typha* and *Cyperaceae* increased since 1930 AD in all sites, as the wetlands responded to lake water level change caused by deforestation and agricultural activities. The results of this multi-proxy study help understand the long-term relationship between natural and anthropogenic environmental change in NE China.

12-O Rapid response of testate amoebae to wildfire in a peatland in NE China.

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Many peatlands are exposed to intermittent burning but the implications of this burning for microbial communities have been little-studied. Here we consider the impacts of burning on the dominant protists of peatland ecosystems, the testate amoebae. To do this we used a 'natural experiment', a peatland exposed to wildfire where fire-fighting activity left a combination of unburned and heavily burned areas in close proximity. We assessed the change in testate amoebae three days after the end of the fire. We find that burning led to a large change in taxon composition, primarily noted by a shift from taxa with tests constructed of idiosomes to those constructed of xenosomes. The most likely explanation for this change is the direct destruction of mostly idiosome tests by extreme heat. Although we did not differentiate live individuals from empty tests it is probable that the fire led to a significant change in the testate amoeba community. This change may have interesting implications for the structure of microbial food webs, for biogenic silica cycling and for palaeoecological reconstruction in burned peatlands. This is clearly a topic which deserves more research attention.

12-P Environmental change and biological response during the past 200 years from two alpine lakes below and above modern treeline in southwest China.

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Southwest China, which includes the eastern margin of Tibet, is a hotspot of global biodiversity. Two alpine lakes, one is Jiren Lake, located above the modern treeline, from Yajiang county in Western Sichuan Plateau, and the other is Cuoqia Lake, located below the modern treeline, from Shangri-La city in northwest Yunnan, are selected. Multi-proxies (i.e., cladoceran, diatom, geochemical) from two Lakes sediment cores were analyzed, to reconstruct the environment change history of two Lakes, and to understand how lake physicochemical characteristics and catchment characteristics from lakes above and below treeline affect the pattern of aquatic organism's response to environmental change. The composition of cladoceran are different in two oligotrophic lakes, littoral species (*Alona* spp., *Pleuroxus* spp. etc) and ubiquitous species *Chydorus sphaericus* are dominated in Jiren Lake, while the Cuoqia Lake was predominated by planktonic cladocera *Daphnia longispina* with rare littoral species. The diatom assemblages at Jiren Lake was dominated by small *Fragilaria* and *Cyclotella*. *Aulacoseira* spp. and benthic species were dominant at Cuoqia Lake. Over the last 200 years, cladocera and diatom composition all showed obvious changes, while, there are subtle changes of diatom and only absolute fluctuation between the dominate cladoceran species *Daphnia longispina* versus

predatory species *Polyphemus pediculus* at Cuoqia Lake. Our results indicate that, the composition of aquatic organisms (cladoceran and diatom) and their response to regional environmental change are mediated by lake altitude, lake physicochemical characteristics and morphology and catchment characteristics. Low altitude and higher water temperature in Cuoqia Lake promote the growth of planktonic, for the case of Jiren Lake, high DOM and DOC taken from the catchment not only provide more available food for cladoceran, but also reduce the water transparent and UV, and then benefit the survival of planktonic species in the open water zone.

12-P Late Holocene palaeoenvironmental reconstruction from the Great Hinggan Mountain inferred from diatom assemblages.

Yang Sun, Chuanyu Gao, Jinxin Cong, Guoping Wang

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The Great Hinggan Mountain, which located at the northern margin of the summer monsoon, has a typical continental monsoon climate in the southern cold-temperate zone. Due to the East Asian summer monsoon and the westerlies, the climates forcing mechanisms in this region are complex and historical environmental characteristics are necessary to reconstruct for evaluating the climate forcing mechanisms. However, few studies have focused on these topics in this region. To address these gaps, palaeoenvironmental characteristics in Northern Great Hinggan Mountains during the late Holocene were reconstructed based on diatom assemblages in one peat sequence (TQ1) in this study. Results showed that four diatom zones were identified during the last 3300 cal a BP. From 3300 to 2800 cal a BP, *Achnanthes nodosa* continued as the dominant taxon and proportions of *Aulacoseira italica* slightly increased, which meant the climate during this period was cold and humid. From 2800 to 1500 cal a BP, the proportions of *Aulacoseira italica* and *Aulacoseira alpigena* were increased and *Achnanthes nodosa* decreased, and indicated the climate was a bit warmer than the previous period. The numbers of diatom species were started to decrease markedly after 1500 cal a BP. Between 1500 and 500 cal a BP, the proportions of *Eunotia paludosa* started to increase and *Aulacoseira italic* decreased, which might indicate the climate became drier and the surface water of peatland became more acidic. Since 500 cal a BP to present, the decreasing proportions of *Eunotia paludosa* indicated the surface water depth in studied peatland decreased obviously. The dry climate and the increasing of local human activities were speculated as major factors that caused surface water depth decreased during this period.

12-P Long-term ecological responses to hydrologic changes and recent eutrophication in Chenghai Lake, southwest China.

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Surface waters in China have experienced increasing pressure derived from multiple stressors such as eutrophication, water diversion and extreme climate. Despite of intensive measures taken for water protection, a lack of continuous water monitoring data has prevented the effective restoration of impacted lakes. This study combined paleolimnological techniques with archived data to quantify the long-term ecological changes in a plateau lake, Chenghai Lake, for the last three centuries. Chenghai Lake, a meso-eutrophic, large and deep system, has displayed a trend of eutrophication recently, and this lake is currently a closed system as it has experienced a long history of water level drop due to damming. Sedimentary records show that primary productivity has increased significantly in the past few decades. Sediment grain size data indicated pronounced hydrological fluctuation and extreme climate events implying the significant impact of both climate change and water diversion projects. Principal component analysis (PCA) results showed

that diatom assemblage had been significantly driven by nutrient enrichment and hydrological changes. Nutrient accumulation accounted for more than 80% of the diatom changes over time in Chenghai Lake, with hydrological fluctuation explaining 9.7%. Compared to the previous studies based on invertebrate biota such as chironomids and cladocerans, diatom assemblages showed a more susceptible to hydrological fluctuation. Our results highlight that the control of eutrophication and hydrological fluctuation should be considered in restoring ecosystem health of Chenghai Lake, and multiple biotic indicators should be applied to provide an integrated perspective for ecological assessment of impacted lakes.

12-P Asynchronous responses to anthropogenic activities of two lakes along urban-to-suburban gradient.

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Differences in types and intensities of human activities often lead to urban-to-rural gradient in the functioning of ecosystems. In order to understand the effect of industrial and agricultural development on freshwater ecosystems, our study cored from urban Shahu Lake and suburban Yanxihu Lake in Wuhan (central China). Multiple proxies, including subfossil chironomid and trace elements, were used to reconstruct the ecological trajectories in two lakes during the past 200 years. Combined with historical data of regional human activities, the potential factors driving limnological changes were also discussed. The results revealed that 1970s-1980s was the crucial period of regime shifts in lake ecosystems in Wuhan. The eutrophication process was earlier in suburban Yanxihu Lake than in urban Shahu Lake. The causes may be the fact that soluble nutrients carried by agricultural sewage in suburban areas are more likely to lead to eutrophication than granular nutrients in urban industrial and domestic sewage, but effects of pollutants in industrial sewage are more severe on urban waters. Water quality of urban lake improved under treatment in recent several years, but continuing deterioration was shown by suburban Yanxihu Lake. This suggested that it is urgent to strengthen the management on non-urban lakes, and the control of agricultural non-point source pollution is difficult but crucial. This study suggests that information on trajectories and drivers of lake development is the premise of effective restoration strategies, and will provide case study and basic data for restoration of different lakes along urban-rural gradient.

13.Resilience and regime shifts in aquatic ecosystems

13-O Regime shifts of Yangtze subtropical shallow lakes: multi-lake comparison, long-term monitoring, and pond experiment.

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Regime shifts between macrophyte-dominated clear-water state and phytoplankton-dominated turbid-water state have been widely reoported. On the alluvial plain of the Yangtze River with a dominance of subtropical climate, there are hundreds of shallow lakes. This major geographical area with its well-developed water system and fertile soil was one of the “cradles” of Chinese civilization. However, many lakes in the basin have suffered for decades from cultural eutrophication and fishery over-exploitation, causing increased phytoplankton, deteriorated vegetation and lowered clarity. In this talk, I’d like to introduce our study on regime shifts in these subtropical shallow lakes. Based on a combination of multi-lake comparisons and long-term monitoring, we analyzed the existence of alternative states, thresholds of total phosphorus and turbidity for the regime shifts, potential effects of intensive aquaculture and high

ammonia concentration, maintenance of alternative states.

13-O Elucidation of wetland functioning based on a mechanistic eutrophication model.

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In this study, Wetland Eutrophication Model (WEM) is introduced, aiming to explicitly account for the ecological interplay among phytoplankton, macrophytes, and sediment diagenesis in Cootes Paradise Marsh, one of the most degraded Great Lakes wetland in Southern Ontario, which has experienced a 90% decline in macrophyte coverage over the past 50 years. To examine WEM's capability of depicting wetland dynamics, we use two sensitivity analysis methods: multiple linear regressions and Self-Organizing Maps (SOM). We describe the mechanistic foundation of WEM that can represent two alternative stable states induced by positive feedbacks associated with resource competition between phytoplankton and macrophtyes in a wetland. Our analysis shows that residual variability increases in linear regression, when ecological parameters are considered in the sensitivity analysis, and thus SOM analysis is more suitable to elucidate complex non-linear patterns and to identify model sensitivity. From the results, we learn from the WEM that the potential regime shift (for recovery) of complex wetland ecosystems should not be based merely on external loading reduction but also be based on in-depth understanding of nutrient recycling in consideration of the interplay among phytoplankton, macrophytes, and sediment diagenesis.

13-O Did recent regime shifts occur in East Taihu Lake? An analysis based on monitoring data and paleolimnological records.

Qi Lin, Ke Zhang, Ji Shen

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Lake ecosystems can exhibit abrupt, but persistent, ecological changes preceded by the erosion of ecological stability and resilience driven by extrinsic (e.g. climatic change and nutrient loading) or intrinsic (e.g. competition and trophic cascade) pressures. In shallow lakes, regime shifts are typically characterized by rapid ecological degradation and catastrophic transition from macrophyte (clear water regime) to phytoplankton (turbid regime) domination under increasing anthropogenic pressures. However, the inference and diagnosis of regime shifts remains large uncertainties due to the rapid changes in external drivers and nonlinear ecological responses. Here we combine palaeolimnological records and limnological monitoring data to investigate the ecological patterns and processes in East Taihu Lake, which was affected by agricultural reclamation and aquaculture. We focused on the examination of recent regime shifts in this shallow lake using chlorophyll and carotenoid pigments (algae), n-alkanes (algae and macrophyte) and organic matter sedimentary records, in concert with limnological data sets on nutrient concentrations, water clarity, chlorophyll-a and water depth. Following the breakpoints detection techniques including sequential Student's t-test algorithm, F-statistics and cumulative sum of difference, the abrupt aquatic ecological changes were identified. Based on the exploration of complex underlying mechanisms, our study diagnosed the significant regime shifts (around the 2000s) in this shallow lake and inferred the potential causation. We argue that adaptive management requires to be flexible and incorporate lessons from the past, e.g. referring to the ecological background and regulating potential pressures (e.g. nutrient loading), and enhancing ecosystem resilience to reduce the possibility of crossing thresholds of change.

13-O Risk, resilience and retention in wetland ecosystem, evidence from sedimentary records in the Sanjiang Plain, Northeast China.

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The nutritional status of lake ecosystem is widely used to assess the resilience and early-warning signals under the disturbance, and the tipping point in nutritional status is considered as the early-warning signal in the lake ecosystem. For wetland ecosystem, nutrients and pollution-related elements could be retained and may not destroy the system structures. While, it is still unclear on how to identify early-warning signals in the wetland ecosystem. Sanjiang Plain (Northeast China) is one of the major wetland distribution regions in China, and most of the wetlands in this region disappeared or degradation. The early-warning signals and resilience under the increased disturbance are important for regional remained wetland protection and restoration. For identifying the early-warning signals and evaluating the wetland resilience in the Sanjiang Plain, geochemical indicators from 7 wetland cores and ecological indicators from 1 wetland core were analyzed to evaluate historical variations of wetland ecosystem in the Sanjiang Plain during the last 150 years. T-test analysis of regime-shifts (STARS) algorithm and principal component analysis were used to identify the regime-shift point for geochemical indicators and ecological indicators, respectively. More pollution-related elements started to accumulate and wetland ecosystem were influenced by human activities after 1920 CE in the Sanjiang Plain. The ecosystem structures keep no obvious change due to the resilience of wetland ecosystem before the 1970s. With the degree of regional human activities increasing, the regime-shift for geochemical indicators occurred around the 1970s CE and dominant species also started to change. Owing to the retention of plant and diatom communities in wetland ecosystem, regime-shift for ecological indicators occurred at 1990 CE. The environmental characteristics (e.g. water table, heavy metals enrichment factors and plant communities) of wetland in the Sanjiang Plain around the 1970s CE can be used as early-warning signals for regional wetland protection and restoration.

14. Water quality management and restorations of aquatic ecosystems

14-O The potential impact of installing a fish pass on the outflow from Loch Leven, Scotland-is it better to be connected?

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Loch Leven is an internationally important shallow lake in Scotland, UK. In the mid 1830s, sluice gates were installed on the outflow from the lake to provide a reliable water supply to downstream industry. These gates prevented migratory fish from entering or leaving the lake via its outflow, and fish such as Salmon and arctic char were lost from the system. By the late 1970s and early 1980s, the lake had become very eutrophic and algal blooms were common. In the 1990s, restoration targets were set and phosphorus inputs were reduced from 20 t y^{-1} in 1985 to about 8 t y^{-1} by 1995. After a long period of recovery, the site is now showing significant improvements in water quality, biodiversity and ecosystem service provision, and algal blooms are now much less frequent. To comply with the requirements of the EU Water Framework Directive, it has now been proposed to install a fish pass on the outflow to enable migratory fish to enter the lake, again. However, concerns have been raised about the possible impacts of this on lake water quality. We

used the computer model PCLake to explore the likely impacts that fish, such as roach, might have on the lake if they were allowed to enter it via a fish pass. By manipulating the fish migration and reproductive parameters in the model, we assessed the potential impact of allowing planktivorous fish, such as roach, into the lake. Our results suggested that this would decrease the level of zooplankton, and zooplankton grazing, allow algal biomass to increase and algal blooms to reappear. We concluded that changing the connectivity of the system in this way could reverse any improvements in water quality that have been achieved by reducing phosphorus inputs.

14-O Restoration of two Chinese subtropical shallow eutrophic lakes: special focus on the interactions between fish and submerged macrophytes.

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Biomanipulation based on removal of coarse fish, piscivorous fish stocking and sometimes also planting of submerged macrophytes has been used to restore temperate eutrophic shallow lakes. However, in warm lakes omnivorous and/or herbivorous fish are more abundant and apparently less well controlled by the piscivores. Here, two subtropical restored (using fish removal and transplantation of submerged macrophytes) shallow lakes, Lake Wuli (5 ha) with a mean depth of 2.1 m and Lake Qinhu (8 ha) with a mean depth of 1.5 m, were investigated in order to describe the food web structure and energy pathways. Omnivorous fish (*Hemiculter leuciclus*, *Pseudorasbora parva*, *Carassius carassius* and *Acheilognathus macropterus*) dominated the fish community in terms of numbers in Lake Wuli. Stable isotope analysis (SIA) combined with IsoSource modeling showed that all adult omnivores fed mainly on macrophytes, while junveniles preferred zooplankton. Furthermore, piscivores consumed shrimps rather than juvenile omnivores, and the SIA analysis revealed no clear trophic links between piscivores and adult omnivores. In Lake Qinhu, grass carp apparently shifted the dominance of *Vallisneria spinulosa* and *Ceratophyllum demersum* in September (when no grass carp were caught) to dominance of *Myriophyllum spicatum* in December through stronger selective feeding on *V. spinulosa* and *C. demersum* than on *M. spicatum*. Thus, in Chinese warmer lakes, submerged macrophytes may constitute an important food item for omnivores, potentially promoting the growth of the omnivore population due to weak piscivore control. This, in turn, may yield a high predation pressure on zooplankton and high grazing pressure on macrophytes. Re-establishment of macrophyte communities is a key tool in the restoration of warm eutrophic shallow lakes, and may need to be supported by control of omnivorous and herbivorous fish when they become abundant.

14-O Effects of the impounding process in flood season on algal blooms of Xiangxi Bay in the Three Gorges Reservoir, China.

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Algal blooms have been a serious problem in tributary bays of the Three Gorges Reservoir (TGR), change of the hydrodynamics has been widely accepted as a target to control algal blooms. Aiming at studying the influence of the impounding process in flood season on algal blooms in Xiangxi Bay (XXB), tracking monitoring of XXB was conducted from June 18, 2017 to July 18, 2017. Based on the laterally averaged two-dimensional hydrodynamic and water quality model (CE-QUAL-W2) of XXB, this study analyzed the temporal and spatial variations of flow, water

temperature, chlorophyll-a (Chl-a) during the impounding process. The results showed that during the impounding process, the total Chl-a in the euphotic zone of XXB (SA) decreased obviously compared with that on July 1; the stronger water temperature stratification was, the greater Chl-a concentration would be; the variation trend of the depth of the plunge point of density currents was consistent with that of SA, the depth of the plunge point decreased gradually, and water temperature stratification was weakened consequently. CE-QUAL-W2 model was suitable for water quality forecasts in XXB, and would play an important role in the ecological reservoir operation.

14-O Comparison among three types of artificial spawning substrates as media to support reproduction of indigenous fish in Liangzi Lake, Yangtze River Basin, China.

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The loss of natural spawning grounds of fish in lakes hinders the natural enhancement of fish resources. In order to increase the natural reproduction of indigenous fish, an experimental program was undertaken to facilitate reproduction by providing artificial spawning substrates. Three types of artificial spawning substrates (palm sheet, polyethylene mesh, polyethylene sheet) were used to construct a multi-level and multi-dimensional artificial spawning ground in Liangzi Lake, China. From 21th March to 30th May in 2018, daily changes in the amount of fish eggs attached to the substrates and the water environmental factors were monitored. The results show that the peak of fish spawning occurred in early April, which is mainly related to water temperature. Eggs attached to the substrates were collected for hatching. The fish species spawning in the artificial spawning substrates were dominated by common carp (*Cyprinus carpio*) and crucian carp (*Carassius auratus*). Dual-frequency identification sonar (DIDSON) was used to observe the spawning time, the spawning behavior and the size of spawning population on the artificial spawning substrates. Fish spawning time is concentrated in the second half of the night. The above results manifest that artificial spawning substrates function effectively in respect to supporting reproduction for indigenous fish in lakes, thereby contributing to the fisheries enhancement for indigenous fish.

14-O Application of a 3D hydrodynamic-biogeochemical model in optimizing water quality restoration and management in a eutrophic riverine estuary (Swan River, Perth).

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The presence of anoxia and hypoxia is often observed in the bottom waters of Swan River (Perth), as in many other eutrophic riverine estuaries, and remains a management challenge due to detrimental effects on aquatic biodiversity and overall amenity. A multi-pronged strategy including catchment nutrient reduction and artificial oxygenation has been applied to tackle the problem of eutrophication. In this study, we present the development and application of a three-dimensional hydrodynamic-biogeochemical model (TUFLOW-FV+AED2) to simulate water quality dynamics in the Swan River in response to the restoration engineering measure of artificial oxygenation, and assess the cost-benefit of different oxygenation operation regimes (e.g., night operation, all day

operation or tidally-optimised operation). The model accurately captured the salt-wedge dynamics and the areal extent and severity of hypoxia under low and high flow conditions. The scenario assessment revealed a two-term power relationship between total oxygen supply and areal benefit, with scenarios highlighting that adding more oxygen improves the oxygen conditions to a greater extent up to a limit (i.e., the law of diminishing returns). The total areal benefit achieved was found to be dependent on the total oxygen load rather than the timing of the oxygen input regime. The modelling results also suggest that when designing an artificial oxygenation plant for an estuarine environment, the locations of oxygen addition should be carefully selected to best use the hydrology to achieve optimum results in target areas. As an extension of the analysis, we developed a real-time simulation platform (Swan-Canning Estuary Virtual Observatory) that provides public accessibility to real-time (5-day past + 5-day predicted) water quality change across the whole Swan River. The platform has assisted in furthering our understanding and appreciation of the Swan River water quality, and has been successfully applied to assist management responses to recent flooding events.

14-O High-throughput sequencing analysis of gut contents comparison between Silver carp and Bighead carp in mesotrophic lake and eutrophic lake.

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We used high throughput sequencing method to classified and compared food composition in gut content of Silver carp (*Hypophthalmichthys molitrix*) and Bighead carp (*Aristichthys nobilis*) in Lake Qiandao (mesotrophic lake) and Lake Taihu (eutrophic lake). In Lake Qiandao, the silver carp fed mainly on Chlorophyceae, Scenedesmaceae, unclassified sample, Chlorellaceae and Chroococcales, respectively, while the bighead carp fed mainly on Diaptomidae in May. Moreover, the relative abundance of microorganism in gut content of silver carp and bighead carp in August were similar. Both carps fed mainly on Chroococcales, while the bighead carp also fed on unclassified sample and Diaptomidae, respectively. In addition, the relative abundance of microorganism in gut content of silver carp and bighead carp in November indicated that both carps fed mainly on Chroococcales. Silver carp fed mainly on Chroococcales, Chlorophyceae, Scenedesmaceae, Chlorellaceae and unclassified sample, respectively. In contrast, bighead carp fed mainly on Chroococcales, unclassified sample and Diaptomidae, respectively. In Lake Taihu, the most abundance of microorganism in gut content of both planktivorous carps was Chroococcales in May, July and August. It was indicated that silver carp fed mainly on phytoplankton and bighead carp fed mainly on zooplankton. However, in the presence of alage blooms in water bodies both carps fed mainly on phytoplankton.

14-O A real-time sampling experiment to assess the impacts of cattle access on freshwater biogeochemical parameters in a farmland stream.

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Freshwater pollution related to livestock is a major environmental problem in agri-ecosystems. Unrestricted cattle access to riparian areas and watercourses has the potential to contribute to

water pollution by increasing the input of nutrients, sediments and faecal contaminants. In the present study, a real-time sampling programme was conducted to assess the impacts of cattle in-stream activity on freshwater biogeochemical parameters including total and dissolved nutrients, total suspended solids (TSS) and faecal indicator bacteria (FIB). A number of events were sampled at an actively used cattle access site, aimed at capturing both periods of cattle in-stream activity and periods of cattle absence. On each occasion, two autosamplers (HACH AS950) were set to collect water samples upstream and downstream of the site at 12 minutes intervals, while motion-activated cameras (Bushnell Trophy HD 119676) were used to determine the timing of cattle in-stream activity, as well as cattle numbers and episodes of direct defecation or urination in waters. We observed that cattle in-stream activity generally resulted in increased water concentrations of FIB, NH_4-N, total phosphorus (TP) and TSS. For instance, on a typical event where, for a period of approximately 24 minutes, at least one and as many as six animals entered the stream, and where one defecation and two urination episodes were observed, the levels of E. coli in waters downstream of the site increased by two orders of magnitude from 10^2 CFU 100 ml^{-1} to 10^4 CFU 100 ml^{-1}, while NH_4-N, TP and TSS concentrations increased from 0.03 mgL^{-1} to 0.08 mgL^{-1}, 68 µg L^{-1} to 148 µg L^{-1} and 2.8 mg L^{-1} to 27.4 mg L^{-1}, respectively. Concentrations returned to pre-access levels rapidity once cattle left the stream. These results indicate that, for these parameters, cattle in-stream activity can have a negative impact on the overall water quality.

14-O Does hydrological reconnection enhance nitrogen cycling rates in lakeshore wetlands of a eutrophic lake? *Haoping Wu*

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Lakeshore wetlands are thought to be hot spots for biogeochemical processes. However, many lakeshore wetlands have been hydrologically disconnected from the associated lake by levees that have altered the ecosystem services they provide. Lakeshore restoration projects have been undertaken to recover the hydrological connection; however, the effects of the various restoration practices on biogeochemical cycling remain unclear. We compared variations in sediment properties and nitrogen (N) cycling rates to assess the restoration benefits of N removal in a series of recently hydrologically restored lakeshore wetlands, including ponds and bottomlands, of Lake Dianchi, China. The results showed that nitrification rates were generally higher in the ponds, while denitrification was higher in the bottomlands. Hydrological reconnection stimulated development of key soil properties critical for N cycling rates in the ponds, including increases in sediment C and sediment moisture and decreases in bulk density; however, bottomland reconnection decreased sediment C and increased soil moisture and bulk density likely due to erosion by wind-induced wave action. Correspondingly, hydrological reconnection significantly enhanced the sediment N cycling rates in ponds but decreased the sediment N cycling rates in bottomlands over time. Path analyses revealed that substrate characteristics, including sediment moisture, sediment carbon (C) and N availability were the critical drivers regulating sediment N cycling rates. These results imply that the restoration targets could not be met simply by hydrological reconnection. Future wetland restoration requires further understanding of the relationship between changes in sediment properties and restoration and ecological processes.

14-O Challenges for Water Quality Protection in the Environs of Addis Ababa, Ethiopia. *Melaku Getachew[1], Geremew Sahilu[1], Mary Kelly-Quinn[2]*

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Water is vital resource needed for the survival of humans and ecosystems. Developing countries throughout Africa are facing increasing pressures on water resources both in terms of supply and quality. Addis Ababa has several reservoirs and river networks used by the community

and industries. However, water pollution which decreases its quality and quantity is severe. The objective of this review paper is to explore the research to date in the catchment draining the environs of Addis Ababa, presents key results, and highlights knowledge gaps, future research and water quality challenges.

According to several studies, water pollution pressures result from rapid urbanization, inadequate sanitation, poverty, shortage of affordable housing and associated lack of wastewater treatment facilities and law enforcement difficulties. The city hosts about 65% (>2,500) of Ethiopia's industries of which 90 - 96% lack onsite treatment facilities. Consequently, Water resources in the region are severely polluted. For example, the industrial wastewater analysis for BOD and COD were found to be 4,475 mg/L and 14,702 mg/L respectively which are extremely high compared to the standards 80 mg/L for BOD and 250 mg/L for COD. Fear of food poisoning is worsened by the fact that 60% of the city's food consumption is supplied by urban farmers.

Most studies agree that water from these polluted waters should not be used for humans as it could affect the community similar to the deaths from contaminated water, which occurred around Lake Koka in 2009. Therefore, effective monitoring, including development of bioassessment tools, together with cost-effective management measures are needed to reverse the decline in water quality in the country as a whole and in particular in the environs of Addis Ababa.

14-O A Decision Support System framework to evaluate the prospective applicability of biomanipulation for managing eutrophic man-made lakes: lessons from an ineffective, costly South African trial. *Rob Hart*

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Eutrophication is widely recognized as a global problem, seriously threatening both ecosystem and human health. Its direct cause (nutrient pollution) and symptomatic consequences (explosive growth of autotrophs, food-web alteration, degradation of water quality, etc.) are well known. While the problem is fundamentally simple to prevent, diverse practical challenges commonly render 'prevention' inadequate. Consequently - notwithstanding ''prevention being better than cure'- curative remedial/restorative in-lake treatments (e.g. biomanipulation) are used to 'mask' its symptoms. Biomanipulation is the deceptively simple concept of food-web management, encapsulated in the 'trophic cascade' premise. Namely, reduce the abundance of zooplanktivorous fish and/or invertebrates to decrease their predation pressure on herbivorous zooplankton (and other invertebrates), and facilitate consequent increases in herbivore abundance, thereby increasing grazing pressure to reduce unwanted autotrophs. While biomanipulation has been applied globally over decades, its mixed but predominantly unsuccessful outcome highlights the need for fundamental, system-specific understanding of food-web structure (inter alia) prior to embarking on this necessarily ongoing (therefore costly) management approach. Basic lacustrine limnological expertise – in which developing nations are often deficient, is a paramount need.

With no direct evidence unequivocally affirming the success of a decade-long bioremediation 'test case trial' (Harties Metsi a Me) initiated on South Africa's infamously hypertrophic Hartbeespoort Dam in 2008 (costing > US$ 40 million), a Decision Support System (DSS) was developed to guide any future applications. The DSS framework, presented here, examines obvious logical considerations required for any pre-feasibility study. It interrogates the purpose/expected outcome of bioremediation in relation to the physical, chemical and biological features, and present or future primary uses of the target ecosystem. The limno-ecological scope of the DSS covers the morphology, bathymetry, hydrology, general physical and chemical limnology, nutrient loading rates and stores, and the broad structural composition and anticipated/known food-web interactions of planktonic, littoral, benthic and nektonic biota in the ecosystem.

14-O Challenges in linking water contamination, its impacts on freshwater biota and the consequences for ecosystem services delivery.

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Freshwater ecosystems are the source of a wide variety of ecosystem services contributing to human welfare. Proactive management of human impacts is required to sustain or restore the delivery of such ecosystem services. Challenges arise when trying to quantify the link between specific pollutant inputs and the delivery of key ecosystem services. A good body of research is yielding results that can increase understanding of the impacts of individual or combinations of pollution pressures on key taxa, identified as good proxies for ecosystem health. However, this covers only one link in the chain of interactions between human activities and the delivery of freshwater ecosystem services. Models can help in establishing the missing links, both between human activities and water quality (hydrology and water quality models) and also between ecosystem conditions and freshwater ecosystem services (e.g. Bayesian belief networks (BBN), feedback diagrams, empirical models). BBNs are popular tools used to represent expert knowledge, qualitative as well as quantitative, as a glue between these varied sources of specific information about the functioning of the ecosystems. They represents a versatile tool to move forward, both by making it possible to link variables whose interactions are not yet well characterised quantitatively, highlight the grey areas where more work is required and via a sensitivity analysis they can highlight the most important uncertainties in the modelling/management chain. This paper outlines work carried out as part of the ESManage research project in Ireland which is developing a framework of interlinked tools, including hydrological, water quality and Bayesian Belief Network (BBN) models, to embed the ecosystem services approach into policy and decision-making for sustainable management of water resources as required by the Water Framework Directive. Of particular interest is how small-group workshops can be used to populate BBNs and indicate the experts' uncertainties in individual ecological relationships.

14-O Characterization of Chromophoric Dissolved Organic Matter in the Littoral Zones of Eutrophic Lakes Taihu and Hongze during the Algal Bloom Season.

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Chromophoric dissolved organic matter (CDOM) is a key component with a critical role in the littoral zones of eutrophic shallow lakes, yet characteristics of CDOM in these zones remain seldom systematically reported. In this study, the differences in sources, biogeochemical characteristics, and fates of CDOM between the littoral zones of eutrophic lakes Taihu (LLT; frequently occurring algal blooms and longer lake residence time) and Hongze (LLH; no obvious algal blooms and shorter residence time) were compared during the algal bloom season using ultraviolet-visible spectra and excitation and emission matrix spectroscopy combined with parallel

factor analysis. Three humic-like CDOM components (C1, C3, and C4) and one protein-like component (C2) were identified. Results showed that CDOM components were dominated by autochthonal protein-like fluorescent substances in LLT, and terrigenous humic-like materials in LLH, respectively. The CDOM in LLT had a lower molecular weight, humification degree, and aromaticity and a higher microbial process because of algal blooms. Furthermore, CDOM depletion rates in LLT were higher than those in LLH due to a longer lake residence time in LLT. In addition, CDOM shifted from high molecular weight to low molecular weight as the humification degree decreased during the CDOM depletion process. This comparative study showed that algal blooms and lake residence time were the significant factors for distinguishing characteristics of CDOM between littoral zones of shallow lakes on a similar trophic level. This study provides field-based knowledge for remote sensing CDOM measurement and serves as a reference for lakeshore aquatic environmental management.

14-O Phosphate recovery from wastewater using NiFe-LDHs.

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The removal and recovery of phosphorus from wastewater in an efficient and cost-effective way are critical for facing the phosphorus crisis. In this study, the ultra-thin NiFe-LDHs nanosheets with different molar ratio of Ni/Fe are fabricated by a co-precipitation method combined with ultrasonic treatment. The Zeta position and crystallinity play an important role in promoting the adsorption of LDH, which are observed in the relationship between the Zeta position, crystallinity and the molar ratio of Ni/Fe. When the molar ratio of Ni/Fe is 2:1, the amount of phosphate adsorption can reach 248.00 mg/g. The regenerative efficiency of Ni_2Fe-LDHs is still up to 59.2% after adsorption and desorption for six cycles, which shows a great application prospect.

14-O The effect of a large-scale river modification on longitudinal and seasonal patterns of limnological variables in the Nakdong River.

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The Four Major River Project from 2009 to 2011 totaled $ 21 and half of the project was carried out in the Nakdong River. Owing to dredging and the construction of eight weirs, the depth, width, and retention time of the river increased 1-10 m to 10-13m, 100-200 m to 300-350m, and by five times, respectively. To assess the effect of the project on the river, eight water quality variables were measured at three lower-reaches sites (River kilometer, RK: 27, 82, and 107) and two middle-reaches sites (RK: 150 and 182) biweekly or weekly (RK: 27) from 2003 to 2017. Mann-Whitney tests were conducted on summer (June, July and August) and winter (December, January, and February) to compare the pre-project period (2003-2009) with the post-project period (2011-2017). In the post period, the median values of total phosphorus(TP), PO_4-P, and SiO_2 content ($77\mu gL^{-1}$, $29\mu gL^{-1}$ and $2.8mgL^{-1}$, respectively) were significantly lower than those in the pre period ($166\mu gL^{-1}$, $87\mu gL^{-1}$ and $6.42.8mgL^{-1}$, respectively; $p < 0.05$). In winter, chlorophyll a (chl. a) content decreased significantly in the lower-reaches ($64\text{-}18\mu gL^{-1}$ at RK 27), whereas no difference was found in the middle-reaches. In summer after the project, chl. a content showed significant increase only at the lowest site of study, and its mean values increased at the four study sites. In addition, a significant increase in dissolved oxygen (DO) saturations (85-117%) and pH (7.7-8.3) in all the sites suggests increased algal biomass. Previous studies on the Nakdong River reported the dominance of diatoms in winter and cyanobacteria in summer. Our findings indicated that the changes in the biomass of diatom and cyanobacteria were attributable more to other

factors, such as hydrologic variables, than to the nutrient content. Various measures to restore the hydrology and ecology of the current Nakdong River are being considered by the government and academics.

14-O Lake Frøylandsvatn, Norway - A forty-year story. *Å. Molversmyr*

International Research Institute of Stavanger, Stavanger, Norway

Lake Frøylandsvatn in the Jæren region in the South-Western part of Norway suffer from excess nutrients inputs and eutrophication and has been considered one of the most heavily polluted lakes in Norway. Over the years great efforts have been made to reduce nutrient input, but as this is the main area of livestock farming in Norway excess nutrient loading from agricultural activities remains a dominant source.

Lake Frøylandsvatn is also the best investigated lake in the area, with annual monitoring of the trophic state. In addition, several studies have been conducted; from investigating the original state of the lake by paleoecological methods, to quantifying nutrient input from various sources, and investigating the influence of internal loading on the present trophic state.

Environmental objectives have been set based on the European Water Framework Directive's objective of good ecological status, and significant further load reduction is needed to achieve the target level.

In this presentation an outline of trophic state changes over the last 40 years is given, and possible measures for further load reduction and the realism of achieving the environmental objectives that have been set are discussed.

14-O Scientific data based lake management-ongoing Latvian case studies. *Matiss Zagars, Linda Buholce, Marta Dievina*

Institute for Environmental Solutions, Latvia

Sustainable lake management is normally based on scientific knowledge. Despite this lake management activities in Latvia have historically been based on notions of managers rather than scientific knowledge. We here report three ongoing case studies where ecosystem surveys have been conducted to provide data based recommendations for lake management and ecological restoration in Latvia.

The following case studies are described: 1) lake Burtnieks – a large, shallow lake with a high recreational value. Intensive cyanobacterial blooms observed. Management has been limited to fish stocking; 2) lake Aluksne – a mesotrophic lake popular with anglers. Historically high poaching rates. Management has been limited to fish stocking; 3) lake Klaugis – a small, privately managed lake. Intensive cyanobacterial blooms observed. Large quantities of common carp stocked.

In all lakes fish, zoobenthos, phytoplankton communities were studied using standard EU Water Framework Directive methodology. Additionally, zooplankton community, fish growth and feeding were studied. The studies were conducted in summer season.

We found high bottom feeding cyprinid fish biomasses in lake Burtnieks, that was identified as the main reason behind the high in lake P values and the intensive cyanobacterial blooms. Fish community biomanipulation was suggested. Currently a biomanipulation project has started. Lake Aluksne ecosystem was found to be in a good state. Due to ongoing anti-poaching activities the fish community is healthy. Further anti-poaching activities and changes in fisheries regulations were suggested. Currently poaching is eradicated; a bag and size limit for Eurasian perch introduced. The feeding activity of carp was found to be behind the intensive algal blooms in lake Klaugis. Removal of carp was suggested and performed resulting in no algal blooms. Salmonid fish are introduced to the lake.

Overall, we found that the lake managers in Latvia are gradually coming to trust that scientific studies are an integral part of a lake management strategy.

14-O Semi-automated method for detecting and counting cells of cyanobacterial colonies and filaments.

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

14-O Heavy metal contamination and accumulation in soil and plants of Riverine wetlands in the Huaihe River Watershed, China.

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Heavy metals are one of the most serious environmental pollutants in aquatic ecosystems since their accumulation along the food chain poses a public health risk. In this study, we tried to find whether, and to what extent, native plant species may be useful for phytostabilization. The con-centration of several metal elements (Cd, Cr, Cu, Ni, Pb and Zn) in sediment and plant samples collected from different sections of the Suoxu River, located in the Huaihe River watershed, China was investigated. Results show that the concentrations of trace metals in the sediment and plants are similar and are found in the order of Zn > Cr > Pb > Cu > Ni > Cd. Standing stock concentration varied between plants groups and metals. The bio-concentration factor (BCF) and translocation factor (TrF) values were <1 for most of the trace metals, suggesting that the investigated species are no strong accumulators of trace metals, and that translocation from roots to shoots is low. Our study shows that native plant species growing on contaminated sites may have the potential for phytostabilization but not for phytoremediation.

14-P Cyanobacterial removal by a red soil-based flocculant and its effect on zooplankton: an experiment with deep enclosures in a tropical reservoir in China.

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As a one kind of cheap, environmentally-friendly and efficient treatment materials for direct

control of cyanobacterial blooms, modified clays have been widely concerned. The present study evaluated cyanobaterial removal by a red soil-based flocculant (RSBF) with a large enclosure experiment in a tropical mesotrophic reservoir, in which phytoplankton community was dominated by *Microcystis* spp. and *Anabaena* spp. The flocculant was composed of red soil, chitosan and $FeCl_3$. Twelve enclosures were used in the experiment: three replicates for each of one control and three treatments RSBF15 (15 mg $FeCl_3$ l^{-1}), RSBF25 (25 mg $FeCl_3$ l^{-1}), and RSBF35 (35 mg $FeCl_3$ l^{-1}). The results showed that the red soil-based flocculant can significantly remove cyanobacterial biomass and reduce concentrations of nutrients including total nitrogen, nitrate，ammonia, total phosphorus and orthophosphate. Biomass of *Microcystis* spp. and *Anabaena* spp. was reduced more efficiently (95%) than other filamentous cyanobacteria (50%). In the RSBF15 treatment, phytoplankton biomass recovered to the level of the control group after 12 days and cyanobacteria quickly dominated. Phytoplankton biomass in the RSBF25 treatment also recovered after 12 days, but green algae co-dominated with cyanobacteria. A much later recovery of phytoplankton until the day of 28 was observed under RSBF35 treatment, and cyanobacteria did no longer dominate the phytoplankton community. The application of red soil-based flocculant greatly reduces zooplankton, specially rotifers, however Copepods and Cladocera recovered fast. Generally, the red soil-based flocculant can be effective for urgent treatments at local scales in cyanobacteria dominating systems.

14-P Water Quality Characteristics and Influence of Active Volcano in the Azuma River Basin, Gunma Prefecture, Japan.

Yoshihiro Igari, Koji Kodera, Kazuki Asami, Go Yamaki, Masaki Horiuchi

Hosei University, Japan

1. Introduction

Both Mt. Asama and Mt.Kusatsu-Shirane are based on Neogene volcanic rocks, and the water quality unique to the volcanic region appears in the river water. We will try to examine the factors of water environment formation by clarifying the geological structure and land use for each surrounding area.

2. Target area / Research method

In Mt.Asama 26 times from June 2015 to April 2018, at Mt.Kusatsu-Shirane, we conducted 11 field surveys and sampling from May 2017 to April 2018. It is about 80 rivers and 12 precipitation. On-site measurement of AT, WT, pH, RpH, EC was carried out. We also sampled the water and brought it back to the laboratory and analyzed the TOC and the major dissolved components (Na, K, Ca, Mg, Cl, NO3, SO_4) after taking the filtration.

3. Results and discussion

3.1. Mt. Asama On the south side, dissolved matter is very close to each other in the lower river basin and the upper stream area of the Yugawa-River and show different characteristics from the water quality upstream of the river. It is suggested that the groundwater influenced by volcanic gases (Suzuki et al. 2007) flowing into the river at the valley head of the summit area and the cliff line of the plateau at both points both in active forest volcanoes It was.

3.2. Mt.Kusatsu-Shirane Several strongly acidic and high EC river waters, which are thought to have been influenced by the former sulfur mine wastewater, were found in the branch of the Manza-gawa River in the western part of the mountainous area, and some rivers in the center of the survey area, pH:4.0-7.0, EC:200-600μS/cm, with volcanism, mines and mining drainage, influences from the surrounding upland fields are also conceivable.

14-P Water Quality Characteristics and Factors in Islands of Nagasaki Prefecture.

Go Yamaki, Koji Kodera, Kazuki Asami, Yoshihiro Igari, Masaki Horiuchid

Hosei University, Japan

1. Introduction

Research on islands in Nagasaki prefecture has hardly been investigated and research has been promoted since 2014 from Goto Island Islands, Tsushima, Iki, Hirado. For this time, we will clarify the water environment in each area from the relationship with land use and climate, and make it a foothold to clarify the material cycle of each island.

2. Target area

Iki is rugged with a maximum altitude of 213 m, and there are numerous reservoirs in various parts of the island. In Tsushima, the altitude of the entire island is relatively high, and the mountains occupy about 89%. The Goto Islands Island consists of about 140 large and small islands, with large geological differences on each island. The Hirado Islands have many mountains while the fields are also relatively large. The population penetration rate of wastewater treatment in both areas is as low as 20-40%.

3. Research method

Field survey was conducted 2 to 4 times a year from 2014 after organizing and examining existing research. On the site, water temperature, temperature, electric conductivity (EC), pH and RpH, COD were measured, and water was taken to measure the total organic carbon and the main dissolved components.

4. Results and discussion

In Iki, the influence of agriculture appears in EC and TOC, but it is interesting that there is almost no effect of nitric acid. On the other hand, although many nitric acid was detected in the Goto Islands, it is thought that factors are due to paddy fields in Iki and upland fields in Goto Islands. Tsushima showed relatively low concentrations of EC and dissolved components, and seasonal changes also appeared. In Hirado Island, especially in the southern part, the geological influence is large in many places, the impact of sea salt is strong in Ikitsuki island and Azuchi Oshima. EC tends to rise in rainwater from October to March, pH tends to decrease. From the above, it is considered that the difference in the quality of the islands is greatly influenced by the difference of geology, topography and agricultural form.

14-P Water environment study of alpine lakes.

Kazuki Asami, Koji Kodera, Yoshihiro Igari, Go Yamaki, Masaki Horiuchi

Hosei University, Japan

1. Introduction

There are some alpine lakes in Japan, but these are said to be susceptible to the change of the global environment. alpine lake is a place of ecological formation in alpine mountains, research of alpine lake is important to capture the change of the global environment and preserve the environment of the lake. Therefore, Hosei University is working on the study of the water environment of alpine lake since 2013, and here we will report on the results of the alpine lake survey conducted from 2013 to 2017.

2. Target area

The target is alpine lake group in Mt.Ontake, Mt.Norikura, Mt.Hakusan, Mt.Kiso Komagatake at Chubu district, and both lakes are located at a height exceeding 2,500 m above sea level.

3. Research method

Mt.Norikura, Mt.Hakusan, Mt.Kiso Komagatake conducted a survey in August 2014 and Mt.Ontake conducted a survey from 2013 to 2017 in summer. In the field, AT, WT, EC, pH, RpH were measured. In addition, we take water samples, take home the samples, analyze TOC in the laboratory and analyze the major dissolved components.

4. Results and discussion

Most of the alpine lake surveyed is an acidic value around pH 5.0 and EC is smaller than 10 μS / cm. However, in the lakes in Mt.Ontake summit area, there was a difference in pH and EC between the north and south. Since the concentration of sulfate ions is high in the lakes on the south side of Mt.Ontake summit area, the difference in pH and EC of the lakes in the north and

south is considered to be due to the influence of the volcanic gas. Also, after the eruption in 2014, the quality of the lake in Mt.Ontake summit area has changed, especially in Ninooke, the concentration of dissolved components has increased greatly.

14-P Water quality in the Mexico City, Rowing Canal: suggestions for improvement based on enclosure experiments.

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Effective lake management includes biomanipulation and a reduction in nutrient load. The former involves controlling fish densities and increasing the presence of large sized cladocerans and macrophytes in the water bodies. There are fewer studies on biomanipulation in the tropics as compared to temperate regions. The Virgilio Uribe Rowing Canal in Mexico City is used by the local population extensively in spite of toxic cyanobacterial blooms. This water body is filled using treated waste water but the inputs can be controlled. Here we provide a background on physical and chemical variables, zooplankton and phytoplankton community, as well as fish and macrophytes in this waterbody. During an annual cycle 2016-2017, the rowing canal was characterized as hypereutrophic site with a constant presence of cyanobacteria, especially *Microcystis* sp. The chlorophyll a levels ranged between 86-2500 mg m3. We conducted mesocosm experiments and found that the densities of cyanobacteria varied in treatments which included large sized crustaceans (>800 μm) such as *Simocephalus cf. mixtus*, commonly found in this water body. The inclusion of macrophytes also helped decrease the concentrations of nutrients in the enclosures. Based on our experiments, we propose some alternatives to reduce the cyanobacterial densities, and thereby reducing the health risk to the local population from this water body.

14-P Occurrence of particulate-phase polycyclic aromatic hydrocarbons (PAHs) and their relationship with algae blooming in Chinese lakes.

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With the rapid development in China, polycyclic aromatic hydrocarbons (PAHs) together with algae blooming caused by eutrophication have led to worsening environmental pollution, and the lake function and health have been threatening. In a lake ecosystem, particulate-phase plays a connective role in the water-sediment interaction of algae bio-pump. However, the coupling interaction of PAHs and algae were less concerned. Here, we investigated the occurrence and spatial distribution of particulate-phase PAHs of 48 lakes in China and analyzed the correlation with algae blooming. Our results showed the average concentration of 15 U.S. EPA priority compounds, non-priority compounds and total parent PAHs were 1587 ng/g, 213 ng/g and 1999 ng/g, respectively. PAHs of U.S. EPA priority compounds and non-priority compound posed a significant spatial difference.

N-heptadecane was considered as the product of algae. Our positive control illustrated that

the n-alkanes in the cultures of algae during algae blooming was almost constituted by n-heptadecane. Therefore, n-heptadecane was regarded as the biomarker of algae in this study. Correlation analysis showed that n-heptadecane had significantly positive correlation with each PAH compound ($p<0.001$). It indicated that algae played an important role in multimedia transport in lake ecosystem, and algae may increase the ecological risk of PAHs.

14-P Water environment survey and conservation activities in the Shingashi River basin in cooperation with citizen activities.

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Hosei Univ., Japan;

1. Introduction

The river water environment in Japan deteriorated with urbanization, but in recent years it has been improving. However, some urban rivers still have problems with water quality, and it is important to grasp the current water environment of rivers in order to conserve the water environment. Hosei University collaborates with civil society to conduct water quality survey of the Shingashi River basin which runs in the suburbs of Tokyo, and from the results of the water quality survey carried out 5 times in total from 2013 to 2017 here, from the current water environment of the Shingashi River basin.

2. Target area

The Shingashi River basin is located across Tokyo and Saitama prefecture. The mainstream Shingashi River belongs to the Arakawa River water system class 1 river, the flow path extension is 34.6 km, the catchment area is 411 km^2. The main tributaries are originated in the Tokyo metropolitan side and join the Shingashi River in Saitama Prefecture.

3. Research method

In the "Survey of familiar water environments conducted in June every year", citizen groups will provide water sampled, and using TOC, pH, RpH, EC measurements and analyzers in the laboratory, Analysis of major dissolved components is carried out.

4. Results and discussion

As a result of the survey, various water quality is distributed in the Shinagawa River Basin, but in the upstream area of each river, calcium bicarbonate type water quality composition is shown, a tendency to show composition of sodium chloride type in the downstream area is seen, this suggested the effect of domestic wastewater. In addition, because nitrate ions are also detected, it was also predicted that fertilizer application affected rivers.

14-P Response of microbial community composition to habitat restoration in urban river ecosystems.

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Ecological restoration is conducted widespread to restore the degraded river ecosystem worldwide, while habitat restoration is one of the most practical methods used for the river ecological restoration. By driving organic matter (OM) decomposition, whole-stream respiration and carbon, nutrient flow to higher trophic levels, microbial communities play an important role in river ecosystem process and functioning. However, the structure and the roles of microbial communities in promoting river ecosystem process and functioning are less commonly studied when assessing the restoration result. In this research, we studied the benthic bacterial community composition in rivers after 1 to 7 years habitat restoration using high-throughput 16S rRNA gene amplicon sequencing, aiming to investigate how habitat restoration impact on the benthic bacterial community composition, bacterial diversity and functional bacteria in restored rivers. The result showed that both water quality and benthic bacterial community structure were positively affected by habitat restoration. Reduced total organic carbon, dissolved organic carbon and increased

dissolved oxygen concentrations in the surface water were recorded in the restored rivers. Benthic biofilms did not showed a strong response of bacterial richness to habitat restoration, but reduced bacteria diversity and relative abundance of heterotrophs *Bacteroidetes,* a phylum specialized in degrading high molecular weight (HMW) compounds. No significant difference of nitrogen cycling bacteria were recorded in restored rivers, however, habitat restoration induced slightly higher relative abundance of denitrifiers such as *Flavobacterium*, *Decloromonas*, while reverse trend were observed for nitifier *Methylotenera* and organic pollutants degradation genera *Clostridium_sensu_stricto_13* and *Ferruginibacter*, attributing to the status of dissolved oxygen and total organic carbon in the surface water. Our results highlight effective organic pollutants reduction and parallel microbial ecological state of habitat restored rivers, indicating that applying habitat restoration in the restoration of urban rivers could be used for sustainable freshwater restoration and management.

14-P Seasonal Variation of Phosphorus Forms in the Water and Sediment in the Gaoyang Lake of the Pengxi River, Three Gorges Reservoir.

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Water samples and surface sediments, separately collected at four sites in Gaoyang Lake in January 2016 (winter), April 2016 (spring), July 2016 (summer), and October 2016 (fall), were used to determine the total phosphorus, dissolved total phosphorus and orthophosphate in the water and the content of inorganic phosphorus was extracted and determined by SMT extraction to analyze the seasonal variation characteristics of phosphorus in water and sediment. During the study period, the content of TP in water was 0.035-0.215 mg/L, with an average level of 0.068 mg/L; the TP content in winter and spring was higher than that in summer and autumn; the effect of backwater irrigation in the main stream was significant. When the water was not stratified in Gaoyang Lake, the surface, middle and bottom layers had similar concentrations in phosphorus, while when the water stratified, the TP concentrations at the bottom were higher than that at the surface layer. The contents of total phosphorus of the surface sediments in Gaoyang Lake raged from 511.52 mg/kg to 685.95mg/kg, compared with other the domestic lakes' TP contents, it was at a moderate pollution level. The concentration of different forms of phosphorus was ranked from high to low as following order: NaOH-P>Res-P>HCl-P>BD-P>NH4Cl-P, showing that the sediments in Gaoyang Lake were more heavily affected by human activities, with a high potential environmental risk. In time distribution, the content of TP, NaOH-P and Res-P in surface sediments in summer and autumn was higher than that in winter and spring; the trend of BD-P and NH4Cl-P in surface sediments was opposite to that of TP with seasonal changes; there was no significant difference in HCl-P content with seasonal changes. When water was stratified in summer, the water body at bottom was in an anaerobic environment, contributing to the release of phosphorus from surface sediments and becoming the source of phosphorus in water.

14-P Comparison of Four Quantitative Techniques for Monitoring Microalgae Disruption by Low-frequency Ultrasound and Acoustic Energy Efficiency.

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Ultrasound has been regarded as an environmental friendly technology to utilize microalgae biomass and control algal blooms. In this study, four quantitative techniques – cell counting, optical density of algal suspension, pigments release, and protein release, were performed on three species of microalgae (*M. aeruginosa*, *C. pyrenoidosa*, and *C. reinhardtii*) to develop effective techniques for rapid monitoring of cell disruption and to optimize the acoustic energy efficiency. Results showed optical density of algal suspensions was not an optimal indicator to monitor cell disruption, although it is a common technique for determining cell concentration in microbial cultures. Instead, an accurate and reliable technique was to determine the release of intracellular pigments (absorbance peaks of supernatant) for indicating cell rupture. The protein released during sonication could also be a useful indicator if it is the component of interest. A fitted power functional model showed a strong relationship between cell disruption and energy consumption ($R^2 > 0.87$). This model could provide an effective approach to directly compare the energy efficiency of ultrasound in different systems or with varying microalgae species. This study provides valuable information for microalgae utilization, and treatment of algal blooms by ultrasound, so as to achieve energy conservation and environmental safety.

14-P Restoration of Lake Yanglan by combinations of chemical and biological methods.

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In order to restore Lake Yanglan, a eutrophic lake in Hubei, central China, polyaluminium chloride (FAC) was used to precipitate the phytoplankton and nutrients and to increase water transparency after fish removal. Meanwhile, lanthanum modified bentonite (Phoslock®) was applied in order to reduce sediment P release. Water clarity, P and Chl a concentrations showed a fast and dramatic change. Meanwhile, submerged macrophytes were transplanted. One-year data shows that a macrohytes-dominated system has been established with a Secchi depth up to 1.5 m.

14-P Research on Geosmin Removal by Synthesized Ceramic Adsorbent from Bottom Slag and Sewage Sludge.

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In this study, the geosmin (GSM) removal ability using synthesized ceramic adsorbent co-sintered from bottom slag and sewage sludge was investigated. Results suggested that GSM adsorption using the synthesized ceramic adsorbent was described by the pseudo-first order model. The GSM removal efficiency enhanced with the increasing of time, and 81.5% and 76.4% of GSM at the initial concentration of 200 ng L^{-1} and 600 ng L^{-1} was removed after 10 h contact time. The optimum removal efficiency with 82.3% was at pH of 7. The GSM adsorption capability of synthesized ceramic adsorbent increased with the more doge and the maximum was attained at 2 g L^{-1}. The GSM removal efficiency by synthesized ceramic adsorbent was fitted better with Freundlich model than Langmiur model. Moreover, synthesized ceramic adsorbent had a good pH buffering capacity and regenerated ability and removed 76.9% GSM after five cycles. In conclusion, the low-cost and high efficient synthesized ceramic adsorbent was a promising green adsorbent to remove GSM.

14-P Biodegradation of algae-derived organic matter from Lake Taihu.

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Algae-derived organic matter (ADOM) is an important source of autochthonous DOM. The biodegradation of ADOM affects its migration, transformation and function in lakes. In this study, the biodegradation of ADOM, which was extracted from the cyanobacteria in Lake Taihu, was studied at different temperature (T), dissolved oxygen (DO) and A-DOM initial concentrations through optical methods (UV-Vis spectrum and excitation emission matrix fluorescence combined with parallel factor (EEM-PARAFAC) analysis). Four EEM-PARAFAC components, namely C1 (tryptophan-like substance), C2 (UVC humic-like substance), C3 (microbial-derived humuic-like substance), and C4 (microbial-derived humic-like substance) were identified in ADOM with relative abundances of 80.0%, 16.0%, 3.7% and 0.3%, respectively. In general, during the biodegradation, the fluorescent intensities of C1 and C2 continued to decline, while those of C3 and C4 increased to a maxima and then fell. At the conditions of $[DOC]_0$ = 10 mg/L, pH = 8.0, T = 25 °C and aerobic condition, after 14 days of biodegradation, the degraded percentages of DOC, CDOM (in a_{355}) and PARAFAC components (C1-C3) were 61.2%,59.22%, and 83.7%, 49.9%, and 27.4%, respectively. C4 was formed during biodegradation, and 0.77 RU was detected at 14 d. The degradation of ADOM at 25 °C (30 °C) showed that compared to 20 °C, more ADOM was degraded and the degradation of C1 was enhanced. The degraded percentages of DOC, CDOM (in a_{355}) and C1 at 14 d were 56.5%, 42.8%, and 65.1% at 20 °C. At anaerobic condition, the degradation rate of CDOM (in a_{355}) was 52.9%, more C4 was produced. When DOM concentration is high, the degradation of C1, C2, and C3 were promoted and more C4 (1.49 RU was detected at 20 mg/L) was detected. At initial DOC concentration of 20 mg/L, the degraded percentages of DOC, CDOM (in a_{355}), C1 - C3 were 73.6%, 65.9%, 88.7%, 61.7%, 43.3%, respectively, while 50.4%, 39.0%, 66.7%, 41.9%, 20.6% at 5 mg/L, respectively. This study indicated that ADOM was readily biodegraded in wide initial DOC ranges and the products could be controlled by altering the ambient conditions such as water temperature and DO, which was helpful to understand the transformation of ADOM in lakes.

15. Catchment process and nonpoint source pollution control

15-O Long-term chloride quantification in a mixed-land-use watershed (Iseo-Oglio system).

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Many long-term studies have reported a salinization process in lakes worldwide and a sharp increase of chloride in many water bodies, with adverse effects on freshwater ecosystems. Chloride can enter water bodies from both natural and anthropogenic sources. However, human activities play the major role and the recently observed increase in chloride concentrations is thought to be human-caused. Understanding the various set of chloride-related pressures in a mixed-land-use watershed could represent a complex challenge, however this is the only way to put in place a suitable management strategy. In this work, we analyzed long-term records (1993-2017) of chloride concentration and inflow and outflow data of L. Iseo, Northern Italy. This lake, with a volume of 7.6 km 3, is one of the deep south-Alpine Italian lakes, which represent the major Italian freshwater supply, covering the 85% of the total available water volume; thus, a chloride increase in this basin could have important ecological and socio-economic consequences. A specific survey has been performed between February 2016 and May 2017 in the upper Oglio river watershed to understand the sources of chloride pollution in the lake catchment area. To

estimate chloride load and to make available a useful and easy-to-use tool, we developed a new open-source R package, called RiverLoad, to perform the load estimation with different methods (i.e., averaging methods, rating estimators, regression methods). We also analyzed different chemical ions, as sodium, potassium, nitrate-nitrogen, and sulphate ions, to identify the possible sources of chloride pollution. A positive temporal Cl load trend could be highlighted in L. Iseo with an increase of about 33.5% over the twenty-four years analyzed. Chloride load from wastewater treatment plants seemed to be the main source of chloride increase, albeit we highlighted an important winter contribution of road deicing salt.

15-O Phosphate removal from aqueous solution with metal modified biochars.

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Metal modified biochars have recently drawn great scientific attention to be used as potential adsorbents to remove phosphate from the eutrophic lake water, agricultural runoff, stormwater and other polluted water and wastewater. However, there is a lack of research on the direct comparison of the phosphate adsorption capacities of the biochars modified with different types of metals. Moreover, a comparison of the phosphate removal efficiency of the metal modified biochar with that of the conventional metal salt precipitants is also needed for the practical application of this novel material. In this study, Mg-, Ca-, Fe-, and Al-modified and unmodified Phragmites australis biochars were synthesized and used to remove phosphate from the aqueous solution in batch adsorption experiments. Phosphate removal experiments using Mg, Ca, Fe and Al salt precipitants with or without the unmodified Phragmites australis biochar were also conducted for comparison. The experiments show that the phosphate adsorption and phosphate removal efficiency of the four types of metal modified biochars followed the order of Fe-modified > Ca-modified > Al-modified > Mg-modified at the initial phosphate concentration of 5-20 mg P L^{-1} and Ca-modified > Fe-modified > Mg-modified > Al-modified at the initial phosphate concentration of 50-100 mg P L^{-1}. The unmodified biochar released phosphorus into the aqueous solution. However, adding the unmodified biochar and metal salts into the solution increased the phosphate removal efficiency by 30.6-91.7% relative to the experiments with the addition of only metal salts at the initial phosphate concentration of 50-100 mg P L^{-1}. Adding unmodified biochar improves the phosphate removal efficiency of the metal salt precipitants in polluted waters with a high phosphate concentration. Fe-modified biochar is the most promising material for the removal of phosphate from non-point source polluted waters among all the tested biochars and metal salts.

15-O The control of N and P that feeds into Lake Tai by means of paddy fields—simulation, modeling and influence.

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Due to the enhancement of human activity, eutrophication is the main threat to the safety of freshwater ecosystem. Taihu, the third largest lake in china, has been troubled by eutrophication for several decades. Though the eutrophication control of Taihu reaps preliminary fruit, there is still a long way to go. Considering that crop-plantation is one of the main sources of nitrogen and phosphorus in Taihu, this paper presents a method that introduce effluent discharged from crash

crops to paddy field to slow down the process of the eutrophication of Taihu. the utilization of paddy fields to effluent of cash crops was simulated in a laboratory scale and the removal loading of N and P in different growth stages of rice was focused on. Results revealed that N removal loading of paddy fields reached 477, 840, 787 mg • m^{-2} • d^{-1} in tillering stage, jointing stage, heading and flowering stage, respectively, and P 257, 247, 255mg • m^{-2} • d^{-1}, showing that the utilization of paddy fields to control N and P was feasible. Besides, the data of dynamic change of nitrogen and phosphorus in paddy field was collected and molded to forecast the degradation rate of nitrogen and phosphorus in paddy fields. At the same time, the impact to soil and fertilizer was measured. Increasing trend was showed in soil AP, ranging from 243% to 500%. Half of fertilizer could be reduced without reduced yield. Thus, it is feasible to establish a comprehensive management model containing paddy fields and cash crops to retain N and P. Still, related basic data need to be collected or researched for accurate prediction. And potential environmental risk, like soil phosphorus saturation, should be noticed and prevented.

15-O Assessment of the biophysical properties of the faeces of four cage aquaculture species: implications for modelling of solid waste dispersion.

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Fish faeces is a crucial component of solid wastes that can cause the increase in nutrient enrichment of the adjacent water and sediment deposition. To investigate the impact of four fish (channel catfish, crucian carp, bluntnose black bream, bighead carp) faeces from cage aquaculture on the environment and accurate dispersion model, certain characteristics, including settling velocity, water stability and leaching rates of carbon and nitrogen-based nutrients to the receiving water were quantified in the present study. These four fish species were selected from cage stock held onsite, with an average weight of 629.3 g/ind., 283.7 g/ind., 907.6 g/ind., and 1433.78 g/ind., respectively. Faeces settling rates of these fish species were significantly different except the difference between crucian carp and bluntnose black bream. High water temperature can accelerate the faeces settling speed of channel catfish and bighead carp while no significant influence of water temperature was found on the next two fish faeces. The main water absorption period of channel catfish faeces under the water temperature of 10℃, 20℃ and 30℃ were 0 - 2.5 min, 0 - 2.5 min, and 2.5 - 5 min, respectively. The other three fish faeces had the greatest hygroscopicity during the period of 0 - 2.5 min. Mean faeces carbon content of four fish species ranged from 312 mg/g to 386 mg/g, 319 mg/g to 358 mg/g, 301 mg/g to 349 mg/g, and 56 mg/g to 65 mg/g, respectively. Mean faeces nitrogen content of four fish species ranged from 16 mg/g to 27 mg/g, 19 mg/g to 30 mg/g, 15 mg/g to 24 mg/g, and 7 mg/g to 8 mg/g, respectively. These results suggested that feed habit is the main factor that influence biophysical properties of fish faeces. The main nutrient leaching period is 0 - 2.5 min under different water temperatures.

15-O The effects of physical basin attributes and their interactions on runoff generation in the Dongting Lake basin in Hunan Province, China.

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The basin of Dongting Lake in Hunan Province, China has been altered substantially by

human activity. Environmental issues like farmland reclamation from wetlands, land cover change and high frequency of floods and droughts coupled with present and future climate change impacts call for a better understanding of this hydrological system. Several studies were performed to achieve this goal. First the physical attributes soil, vegetation and terrain of spatial units were correlated with their simulated hydrological behavior in SWAT models. The results showed that surface runoff and evapotranspiration are mainly determined by land cover, while interflow and ground water flow highly depend on terrain. The second study focused on soil-vegetation interactions and their effect on hydrology. In a dual approach of field work and SWAT model study in-situ color tracer infiltration experiments were performed which showed that horizontal water movements were stronger under forest land cover than under horticulture. Combinations of SWAT parameters were chosen to represent soil-vegetation interactions and their effect on hydrology was quantified based on multiple simulations. Runoff curve number (CN2), a measure of surface runoff susceptibility, and soil bulk density (BD) showed the strongest interaction-effects on surface runoff, lateral flow, percolation, groundwater flow and soil water content. The interaction-effects between soil hydraulic conductivity and BD were not as strong as those between CN2 and BD, and mostly affected soil water processes such as lateral flow. The strong interaction between CN2 and BD underlines the importance of the soil-vegetation interface for the hydrological behavior of the study area. Interactions affected river runoff minima, maxima and variability. Precipitation led to seasonal patterns caused by dry and wet periods. The results can help to improve climate change and flood and drought mitigation strategies focused on the retention of water in the landscape to balance discharge between dry and wet periods.

15-P Estimation of Net Anthropogenic Phosphorus Input (NAPI) and Driving Force in Kunming From 1980 to 2015.

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Studying the impact of human activities on regional phosphorus input and the analysis of driving force is an important basis for phosphorus pollution control. Based on the NAPI model of human activities, the net phosphorus input of human activities in Kunming from 1980 to 2015 was evaluated by historical statistics and literature. The results showed that: (1) NAPI reached 2415 kg/km² in Kunming in 2015, in which the proportion of fertilizer application and food and feed input each was 50%; (2) NAPI showed significant linear growth trend in Kunming during the study period with an average annual growth rate of 63 kg/km² Kg / km². At that time, NAPI increased eight times; (3) Fertilizer application and food and feed input showed different growth characteristics during the study period, in which the rapid growth of chemical fertilizers during 1980-2003 was followed by Stability, food and feed input showed a sustained growth characteristics, but declined in 2013-2014. The reason of it may be that livestock and poultry farming regulation led to a decline in feed demand.

15-P MUSLE-based risk evaluation of agricultural non-point source pollution in the Pengxi River Basin, Three Gorges Reservoir.

Jiakun Liu

Southwest University, China

Located in the northeast of Chongqing, the Pengxi River is the largest tributary of the Yangtze river in the Three Gorges Reservoir area. The water quality in the Yangtze River depends highly on the water quality of the streams that flow into it, while the total nitrogen (TN) and total phosphorus (TP) in the Pengxi River have exceeded the internationally established concentrations of algal blooms. Based on the MUSLE equation, the risk assessment system, including length-slope factor, vegetation cover, soil type and gully density, was calculated using the GIS

method. Then, we classified the visualized results into five pollution risk classes; established the index of non-point source pollution potential danger(NPSDI) to describe the overall risk level of non-point source pollution; analyzed the spatial distribution characteristics of non-point source pollution risk areas under different land use patterns, elevations, and soil types; simulated a scenario where the cultivated land with a gradient of more than 25 degrees were converted into grassland and then compared this scenario's non-point source pollution risk with the original results. The results indicated that: (1) the NPSDI in the Pengxi River Basin was 3.34 showing that the potential risk of pollution was at a moderate level; (2) the moderate risk area accounted for the largest proportion of 42.0%, and the percentage of the very high risk area was the smallest, covering 1.5%; (3) the risk level reduced from the river channel to surrounding areas and high altitude areas were witnessed a lower risk level; (4) the NPSDI of 6.85 in the other unused land is the highest, and the dry land had the second high NPSDI of 5.34 indicating that the potential risk of pollution in these two types of land use was moderately heavy; (5) the NPSDI of lime soil is the highest, with a number of 4.36, and the purple soil was correlated with the lowest NPSDI of 2.63; (6) the NPSDI decreased by about 3% compared with the original scenario.

15-P Best Management Strategies to Nitrogen and Phosphorus Loss in A Small Catchment of the Three Gorges Reservoir Area——an Annagnps Based Case.

Jinzhu Wang, Ming Gao

Southwest University, China

Non-point source pollution has the characteristics of randomness, the influencing factors of which are complex, and the influences are often hysteresis. A mathematical model is needed to simulate the formation, migration, and transformation of non-point pollution under complex situations, which is also useful in designing corresponding management strategies. We select the Small Catchment of the Three Gorges Reservoir Area as a target area, a database, based on AnnAGNPS model, is built to store the basic data as soil, plants, fertilization, and management. After calibration, the model can be used to simulate the non-point pollution of the target area. The simulation deviation of runoff is between 16%~19%, TN (total nitrogen) and TP (total phosphorus) are -25.27%~29.14% and 19.28%~37.78%. The simulation performance is acceptable. Upland cells have the highest output of sediments, TN and TP, which are 24.85 $t \cdot hm^{-2} \cdot a^{-1}$, 63.88 $kg \cdot hm^{-2} \cdot a^{-1}$ and 5.53 $kg \cdot hm^{-2} \cdot a^{-1}$. The simulation of the BMTs (best management strategies) shows that improvements in land use structure have the best performance, which reduces the TN, TP by 54.25% and 63.01%; dissolved and particulate nitrogen also reduced by 47%~68%; transforming slope into terrace can effectively prevent the loss of particulate nitrogen and phosphorus; reduced fertilization technology, protective tillage measures also have an ideal performance, which could be adopted as an effective measure to in reducing the non-point pollution of the research area.

S1. Brian Moss: legacy, lessons and limnology

S1-O The nature of competition between phytoplankton and macrophytes.

Stephen Maberly[1], Jack Jones[2], Daniel Obrecht[2]

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Phytoplankton in the pelagic, and macrophytes in the littoral, are the two major groups of primary producers in inland waters. They have very similar resource requirements and although they access these from slightly different compartments there is sufficient overlap for direct competition and also for indirect interference by altering other characteristics of their shared ecosystem. Anthropogenic nutrient enrichment is widespread as is the consequent shift in the competitive balance from a macrophyte-dominated state towards a phytoplankton-dominated state with very

different structure and function. Brian Moss worked in this general area throughout his career and made early contributions to the mechanisms responsible for macrophyte loss and later helped develop the important concept of alternative stable states. In this talk I will describe resource acquisition by phytoplankton and macrophytes, discuss the mechanisms by which the two groups interact and compete, assess evidence for changes in the dominance of these two groups and speculate on how other environmental changes, such as that of the climate and extreme events, may alter the competitive balance. Finally, the direct and indirect consequences of remediation of inland waters on macrophyte success, and its potential effects on the benefits for human populations, will be discussed.

S1-O Climate change effects on trophic structure in lakes - a comparison of monitoring data from >800 temperate Danish and subtropical Florida lakes.

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With global warming, lakes show enhanced symptoms of eutrophication. Fish become more numerous and smaller, and predation pressure from fish on the water fleas increases. The response pattern may, however, differ with nutrient level. To elucidate this further we conducted a comparative study of monitoring data from >800 temperate Danish (DK) and subtropical Florida (FL) lakes. Key results for summer are: Chlorophyll (Chla) and phytoplankton biovolume were higher in FL lakes, but the Chla/biovolume ratio was smaller. Proportion of cyanobacteria and green algae in terms of biovolume were overall higher, while zooplankton biomass, oxygen concentration and oxygen saturation percentage, and thus net ecosystem production were lower. The pattern in winter was similar as for summer, but differences were as expected higher. Clear differences were also seen along the phosphorus and nitrogen concentration gradient and will be discussed. Our results give further evidence that the critical nutrient threshold for good ecological status will be lower in a warmer world, and more effort is needed to shift turbid lakes to a clear state.

S1-O Using palaeolimnology and archival research to inform conservation of a rare Malaysian flood pulse wetland.

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There are few natural standing waters in Peninsular Malaysia. Tasik Chini is one such rare shallow lake-wetland complex located in the state of Pahang. The lake hydrology is maintained by numerous small rivers that drain the local uplands, and flooding from the much larger Pahang River, which inflows during the wet season. The site is UNESCO-designated for its cultural heritage, including local indigenous communities. The fringing lake-swamp vegetation has rare hydrosere communities. Due to the scarcity of similar sites and long-term monitoring data, deriving targets for conservation of natural and cultural heritage at this site is a challenge. Therefore, we used palaeolimnology (lake sediment cores) in combination with analysis of local documentary archives to understand the nature, rates and drivers of change at this site. Documentary archives indicate multiple changes in the lake catchment in recent decades, including extensive farming in the Pahang River watershed and mining and logging activities in the local subcatchment, which have increased soil erosion and nutrient pollution. A dam constructed in 1995 to boost ecotourism has prevented ingress of polluted water from the Pahang River, but together with ongoing climate change, has altered the natural hydrology of the lake. Pb-210 dating on several cores from the lake basin indicates major increases in sediment infilling over the past 50 years, set against a baseline of much reduced sedimentation rates since the lake formed around 4500 years ago. Diatoms, elemental analysis, chlorophyll and carotenoid pigments, and carbon and nitrogen stable isotopes, indicate large changes in hydrology and water quality over the past 150 years, especially since the 1950s. Together these sedimentary indicators demonstrate major shifts in the ecosystem of this tropical lake system, which were initiated by land use changes and many of which are likely to continue in this rapidly developing region undergoing climate change.

S1-O Nutrients and stoichiometry in Missouri reservoirs. *John R. Jones, Daniel V. Obrecht*

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Analyses of US data suggest lake nutrient stoichiometry is less predictable than nutrient concentrations at a broad regional scale. Herein we test this pattern with long-term data from Missouri reservoirs. As shown previously, some 75% of cross-system variation (n=173) in nitrogen, phosphorus and carbon (particulate and dissolved) is explained by cropland (a surrogate for nutrient loading), depth and hydrologic flushing. Missouri's median N:P ratio of 40:1 (molar) is similar to US reservoirs nationwide. Morphology was important in explaining N:P ratios; depth and the ratio of depth to the square root of surface area (after Osgood, internal mixing increases at low values) accounted for 38% of cross-system variation, suggesting an influence of internal processes. Adding cropland and hydrology explained 56% of N:P variation. The Osgood ratio was most influential mid-sized impoundments (10 to 75 ha, n=98); alone it explained 45% of N:P variation and with cropland and hydrology this increased to 60%. This ratio did not enter into models for smaller or larger impoundments. Among 15 reservoirs (total phosphorus from 10 to 100 µg/L) sampled weekly during one summer, some 87 to 92% of nutrient variation was

explained by cropland and hydrology, while hydrology and the Osgood ratio explained 90% of variation in N:P ratios. High-frequency sampling showed N:P ratios significantly declined during summer in the most productive reservoirs, suggesting the timing of summer sampling is a factor to consider. That cross-system variation in N:P can be explained with morphology and sampling frequency deserves evaluation in other regions and lake types.

S1-O A tribute to Brian Moss and the emerging network of Ethiopian aquatic ecologists. *Luc De Meester*

KU Leuven, Belgium

An important part of Brian's work, also reflected in his excellent book Freshwater Ecology, is his African connection both in terms of capacity building and in terms of having his own visionary ideas on how African wetlands function. In the spirit of Brian, I here take the opportunity to highlight some aquatic ecological research done in Ethiopia as part of capacity building and research programs aimed at interuniversity collaboration. I will highlight some key results of research done in collaboration with researchers at Mekelle University, Jimma University, Arba Minch University and Bahir Dar University. I will highlight the multiplicative effect of capacity building, both in terms of organization of research, follow-up projects, and implementation in a socio-economic and conservation efforts. My talk will reflect feelings of promise and despair on the ecology of African ecosystems and their study. Above all I will highlight how such collaboration is highly inspiring and leads to the development of a broader and deeper perspective on aquatic systems and how they function. In has strongly influenced my thoughts in science and beyond.

S1-P Response of epiphytic algae and submerged macrophyte aggregation to nutrient loading and snail grazing: experimental microcosm study. *Liu Yang[1], Zhengwen Liu[1,2]*

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The relationship between submerged macrophytes and epiphytic algae is closely, and they can be seemed as a aggregation. The aggregation is mainly affected by not only nutrient and light, but also grazer, such as snail, fish, etc. In order to test the response of submerged macrophytes-epiphytic algae aggregation to nutrient loadings and snail grazing, a 30-day outdoor mesocosm experiment was conducted on the north shore of Lake Taihu, China. The experiment set two nutrient loadings (N: 113 μg/(L·d), P: 10 μg/(L·d) and N: 339 μg/(L·d), P: 30 μg/(L·d)) in combination with presence and absence of *Radix swinhoei*. The results showed that: 1) When snails were absent, the abandunce and biomass of epiphytic algae on leaves of *Vallisneria spinulosa*, especially Chlorophyta (*Lyngbya, Scenedesmus* and so on) increased more with more nutrient loading, which restrained the growth and tillering of *Vallisneria spinulosa.* When snails were present, the biomass of epiphytic algae on leaves and filamentous algae in water were all declined signigcantly, which enhanced growth of *Vallisneria spinulosa* in all the treatment, while more high quality food, such as *Lyngbya, Scenedesmus* resulted in faster growth and reproduction of snails and reduced the positive effect on *Vallisneria spinulosa* in group with high nutrient loading. We conclude that increasing nutrient loading can change the community of epiphytic algae and population structure of sails, consequently, affect the submerged macrophytes growth and distribution.

S2. Carbon cycling and greenhouse gas emissions in reservoirs

S2-O Soils flooded in water reservoirs loose 30-50% of their original carbon store.

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The fate of flooded soils after dam establishment has been studied at several reservoirs in France. After flooding, soils evolve in relation to their position in the landscape and that of the water level in the reservoir. In the drawdown zone, soils are eroded and the fine earth supplies the sediment cover downslope. In the permanently flooded zone, sediments progressively cover soils. A part of the original soil properties is preserved, but soils loose large amounts of Fe and Organic Matter. Budgets show that 30 to 50 % of the soil carbon store is lost. This carbon release may fuel GHG emissions after reservoir impoundment.

S2-O Greenhouse gas emission from typical valley-type cascaded reservoirs over the Qingjiang River Basin, China.

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More and more attentions were paid on greenhouse gas emission from hydropower reservoirs in recent years. Among greenhouse gas emission, carbon dioxide and methane emission from the interface between water and atmosphere was one of the main pathways from the reservoir. So, the Shuibuya Reservoir and the Geheyan Reservoir over the Qingjiang River Basin were selected as typical valley-type cascaded reservoirs in China for continuous measurement for three years in this paper. Carbon dioxide and methane diffuse fluxes from the typical measurement points such before dam, upstream, tributary, the drawdown area and bay of the cascaded reservoirs were obtained in our measurements. The floating chamber with online greenhouse gas analyzer was used to gauge the concentration change of carbon dioxide and methane in the chamber. And water quality indexes, meteorological parameters and carbon concentration in surface water were also observed at the same time. Data analysis indicated that carbon dioxide and methane average fluxes in the Geheyan reservoir was 55.6918 ± 66.3329 mg • m^{-2} • h^{-1} and 0.1291 ± 0.1820 mg • m^{-2} • h^{-1} respectivly, which displayed the temporal variation of higher in winter and lower in other seasons in one year, but also showing the spatial distribution of lower at the drawdown and higher at typical bay region. Moreover, carbon dioxide and methane average fluxes over the Shuibuya Reservoir showed 38.0524±80.2472 mg.m^{-2}.h^{-1} and 0.1235±0.1801 mg.m^{-2}.h^{-1} separately. The temporal and spatial patterns of carbon dioxide fluxes were significantly affected by water temperature, pH value and inorganic carbon concentration in water. But the relationship between carbon dioxide fluxes and other variables were influenced by seasonal change and impoundment of the cascaded Reservoirs over the Qingjiang River Basin, China obviously.

S2-O Internal and External Controls on Oxygen Consumption and Greenhouse Gas Emission in a Subtropical Hydroelectric Reservoir, Southeast China.

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Seasonal hypoxia (DO<2 mg/L) is common in eutrophic reservoirs. However, major processes and mechanism controlling oxygen level and associated carbon cycling are poorly known. Based on high-frequency observation of water quality, monthly profiling and in-situ incubation, we revealed the external and internal controls on oxygen consumption and greenhouse gas emission in a subtropical hydroelectric reservoir (China). Increased river discharge and storm events (73% of annual runoff) in rain season (March-September) carried a large quantity of particulate organic matter into reservoir. The large catchment/reservoir areal ratio of 526 determines that external organic matter was responsible for oxygen consumption. The primary production to respiration (P/R) ratio of surface water in summer (1.8) was higher than winter (0.5) and the lower C/N ratio (7.1) of top sediment in summer implied that the autochthonous organic matter also contributed to oxygen consumption. The unique hydraulics (effluent exit in the middle of dam) caused three thermoclines and enhanced oxygen deficit in water. As a consequence, hypoxia started in middle July and last 4 months expanding from bottom to near surface water (5.5 m below) before recovery in winter. Microbe respiration accounts for 96% of total oxygen consumption in bottom water in summer but reduced to 67% in winter. We observed greenhouse gases (CO_2, CH_4 and N_2O) produced in bottom water. The reservoir served as a CO_2 source throughout the whole water column with an exception that a sink appeared in euphotic layer (5 m) in summer due to increased photosynthesis. CO_2 was always over-saturated in hypolimnion even in winter under well mixing condition, which will transport downward in effluent and ultimately release to atmosphere as a significant source. This study highlighted the role of eutrophic reservoir in carbon processing with large implication to global climate change.

S2-O The net GHG emissions of Three Gorges Reservoir in China: the contribution of unrelated anthropogenic sources.

Zhe Li

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Dam construction and reservoir creation are thousand-year human activity to regulate water resources for various human needs, supporting well-beings of human on the planet. All human activities have carbon footprints. Reservoir creations are with no exception. Evaluating the net reservoir greenhouse gas emissions are the only possible approach to quantify the contribution of damming and reservoir creation on global climate change. Recently review by Prairie and co-workers proposed a framework to evaluate the net change of biogeochemistry of carbon after reservoir impoundment, i.e. the approach of “What Does the Atmosphere See”. Followed by the framework, the net GHG emissions of the China’s Three Gorges Reservoir are evaluated based on the software platform of DHI MIKE 21+Ecolab. Process-based mechanic model of carbon dioxide and empirical model of methane were built. Models were calibrated with historical water quality parameters and validated with seasonal variations of the baseline year. Resulted showed that unrelated anthropogenic sources from surrounding communities and upstream watershed would support long-term gross emissions of the TGR after its impoundment. It showed a carbon sink, i.e. the negative net GHG emissions, at present status of the reservoir. There is a high possibility to

expect the shifts from carbon sink to carbon source in net GHG emissions about 20 years after the impoundment of the reservoir.

S2-O Greenhouse gas emissions from two reservoirs in the Sanaga River catchment (Cameroon).

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The impoundment of the Lom Pangar Reservoir (540 km²), located in Cameroon, started in September 2015. Although a dedicated power plant was commissioned, the main role of the reservoir is the control of the Sanaga River providing high discharges during the dry season, allowing the efficient hydraulic development of this river. Anticipating significant greenhouse gas (GHG) emissions, the owner of the dam, Electricity Development Corporation, decided to assess the net GHG footprint of the reservoir following international recommendations and guidelines. Two campaigns have been carried out in December 2014 (end of the rainy season) and February 2015 (dry season) in order to estimate pre-impoundment emissions. Both aquatic and terrestrial measurements of CO_2 and CH_4 fluxes (diffusion, bubbling and degassing) have been made during these campaigns. Then, following the partial dam closure, four campaigns have been carried out so far (October 2015, March 2016, November 2016 and February 2017). Only aquatic measurements (dissolved CO_2 and CH_4 profiles, emissions fluxes) were made during campaign for which the reservoir was at its highest level while terrestrial measurements (CO_2 and CH_4 diffusion from soils/sediments) were also made in the drawdown area for campaign at the end of the dry season (lowest water level). Between September 2015 and February 2017 the total emissions amounted to approximately 4.0 ± 0.4 $MtCO_2eq$, ie about 2.9 $MtCO_2eq/yr$. In addition, GHG fluxes measurements have been also made on an old (50 years) similar reservoir in the Sanaga River catchment. These measurements provide a good insight about the expected long-term emissions of the Lom Pangar reservoir. This on-going comprehensive study is the first of this type in Africa to date.

S2-P Assimilation of ancient organic carbon by zooplankton in Tibetan Plateau lakes is depending on watershed characteristics.

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Ancient (i.e. radiocarbon depleted) organic carbon (OC) is exported from ice sheet, glacier and permafrost systems and may be buried, respired or assimilated in downstream aquatic systems. Few studies have explored the potential use of this ancient OC in lake food webs. We combined natural abundance radiocarbon and stable carbon isotope data ($\Delta^{14}C$ and $\delta^{13}C$) to study ancient OC utilization by zooplankton in six lakes covering a large climate gradient on the central and peripheral Tibetan Plateau. A depleted $\Delta^{14}C$ signature of dissolved and particulate OC was found in the inflowing streams and lakes, ranging from -49‰ to -569‰, corresponding to radiocarbon ages between 403 and 6757 years. The $\Delta^{14}C$ values for zooplankton in the lakes ranged from -45‰ to -264‰, reflecting that zooplankton obtain ^{14}C depleted signatures through assimilation of ancient organic carbon and/or indirectly through consumption of phytoplankton or aquatic plant

utilizing ^{14}C depleted inorganic carbon. Moreover, ancient OC from inflowing streams contributed more to zooplankton diets in the temperate glacier area than in the cold glacier area. Assimilation of ancient organic carbon by zooplankton in lakes is not only affected by drainage basin characteristics, such as the recharge coefficient of the lake, but also by the biogeochemical properties of OC. Use of ancient OC by zooplankton in high-altitude lakes may constitute an important link between the contemporary aquatic food webs and the glaciated watersheds. Our findings have important implications for the contribution of ancient carbon to the modern lake food webs of high-altitude and polar lakes.

S3. Connecting freshwater and marine ecosystem-scale mesocosm approaches to ecosystem-scale questions

S3-O Impact of nutrient and water level changes on submerged macrophytes along a temperature gradient: Pan-European mesocosm experiments.

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The ongoing climate change will affect freshwater ecosystems worldwide. In addition to a temperature rise, increased precipitation and enhanced nutrient runoff are anticipated for Northern Europe, whereas decreased precipitation, leading to reduced runoff, drop in water levels and periodic droughts are expected for Southern Europe and the Mediterranean region. To elucidate

the effects of climate changes on macrophyte growth in shallow lakes, we used a space-for-time approach by conducting a controlled and highly standardised Pan-European mesocosm experiment at contrasting depths (shallow and deep) and nutrient levels (low and high), representing mesotrophic and eutrophic conditions, in six countries along a latitudinal temperature gradient from Sweden to Greece. Samplings were conducted monthly for six months to determine physico-chemical variables, light attenuation and per cent volume inhabited (PVI%) by submerged plants. At the end of the experiment, macrophytes were harvested, dried and weighed. During the experiment, overall average temperature gradient was 9ºC. Mean air temperature was the highest in Greece (23.4ºC), followed by Turkey (18.7ºC), and there was a significant water level drop in Greece and Turkey, whereas the water level changed only marginally in the more northern countries. ANCOVA results indicated a significant effect of depth-nutrient and temperature-nutrient interactions on PVI%. Higher PVI% was observed in the shallow mesocosms with both low and high nutrient conditions in the warm countries. We conclude that the combined effects of a moderate water level decrease and a temperature increase overall compensated for the negative effects of nutrients on macrophyte growth by enhancing light availability. Nonetheless, our results also demonstrated that extreme water level reductions, which may become more frequent with global warming, particularly in southern European regions, had adverse effects on macrophyte growth.

S3-O Mesocosms are an excellent tool to show climate change impacts on aquatic ecosystems.

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Through a concerted effort we were able to show the impact of climate warming on different aspects of ecosystem functioning. By studying different components of aquatic pond systems, including fungal infection dynamics of a phytoplankton host, phytoplankton-zooplankton interactions, perifyton dynamics, and methane ebullition, we gained a comprehensive understanding of potential climate change impacts. Warming was able to accelerate termination of a phytoplankton spring bloom by fungal parasites. In addition, warming was able to not only advance top-down control of phytoplankton, but also enhance the overall impact of both bottom-up and top-down control on primary productivity in general. Lastly, we also showed that warming increased methane ebullition, highlighting the potential risk for higher methane emission in a warmer climate. Our mesocosm approach allowed us not only to gain a more mechanistic understanding of potential climate warming impacts, but also showed the added value of team science in doing aquatic experimental research.

S3-O Prolonged flooding nonlinearly affected lakeshore meadow: a water-level control experiment at the whole lake scale.

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Background: In many lakes of the world, human activities and climate change are predicted to change the flooding regime, which could affect lakeshore meadows. However, previous studies

about flooding effects on lakeshore meadows are mainly from greenhouse experiments or investigations along nature flooding gradient. It's still unclear how prolong flooding affect ecosystem processes due to lack of experiments at the lake ecosystem scale.
Methods: Therefore, in Poyang Lake area, China, we investigated two neighboring lakes with different flooding regime: one lake had nature flooding regime and the other one had artificially prolonged flooding duration. These two lakes were separated by a 3m-height levee and connected during the flooding season when water level is higher than levee. In each lakeshore, we set 30 sampling sites from low to high elevation, and therefore we had 60 sampling sites with different flooding duration.
Results: (1) prolonged flooding non-linearly affected aboveground biomass, which peaked at intermediate flooding duration (about 240 days), but increased root biomass. (2) Prolonged flooding had no significant effects on plant diversity while increased the dominance of low elevation species. (3) Prolonged flooding decreased rhizome biomass and inhibited the dispersal of seeds with long dispersal ability, suggesting that prolonged flooding increased recruitment limitation. (4) Prolonged flooding nonlinearly increased soil C, N and P content and peaked at intermediate flooding duration (about 240 days), thus increased leaf N and P content. As a result, the visits of wintering birds increased by prolonged flooding.
Conclusions: Our results suggested that prolonged flooding not only affect plant growth as reported from small scale study, but also significantly affect ecosystem processes including seeds dispersal, soil properties, and wintering bird visit. Therefore, our study highlight the importance of ecosystem scale studies to understand comprehensive effects of environmental changes on ecosystem processes.

S3-O Consumer adaptation mediates top-down regulation of ecosystems across a productivity gradient.

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Humans have artificially enhanced the productivity of terrestrial and aquatic ecosystems on a global scale by increasing nutrient loading. While the consequences of eutrophication are well-known, most studies tend to examine short-term responses relative to the time scales of heritable adaptive change. Thus, the potential role of adaptation by organisms in stabilizing the response of ecological systems to such perturbations is largely unknown. We tested the hypothesis that prior local adaptations by a generalist consumer (*Daphnia* pulicaria) to toxic prey (*cyanobacteria*) mediates the response of lake ecosystems to nutrient enrichment. Overall, the magnitude of the *Daphnia* effect on primary producer biomass increased with productivity. However, these effects were contingent on prey traits and consumer genotype (i.e., tolerant vs sensitive to toxic *cyanobacteria*). Tolerant *Daphnia* strongly suppressed toxic cyanobacteria in nutrient-rich ponds, but sensitive *Daphnia* did not. Our results demonstrate that organismal local adaptation is critical for understanding and predicting ecosystem-level consequences of anthropogenic environmental perturbations.

S3-O Effects of high ammonium on sediment phosphorus release: mesocosm experiment.

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In aquatic ecosystems, ammonium is one of the dominant substances in effluent discharge of waste water and its impact has been widely explored as it is thought to cause stress on organisms in its toxic form (NH_3). Little is, however, known about its potential effect on the release of phosphorus (P) from the sediment. We tested if high loading of ammonium promotes the sediment release of phosphorus in a two-month mesocosm (150 L) experiment and explored the dominant underlying mechanisms. A gradient of five target ammonium loading levels was used by adding NH4Cl: no addition/control (N0), 3 (N1), 5 (N2), 10 (N3), and 21 (N4) mg NH_4Cl L^{-1} (NH_4Cl expressed as nitrogen). We found that: 1) The total phosphorus concentration (TP) of overlying water was significantly higher in N3 and N4 than in the controls, but not in N1 and N2; 2) In situ DGT (diffusive gradients in thin-films) measurements at the sediment-water interface showed significant P release for N3 and N4 but minor release or retention for N0, N1, and N2; 3) Overall, TP correlated significantly and positively with total nitrogen concentration (TN) in the water. Further correlation and path analyses suggested that decreased dissolved oxygen (DO) levels (an approximate drop from 9.2 to 6.6 mg O_2 L^{-1}) and a stimulated alkaline phosphatase activity (APA) were likely the dominant mechanisms underlying the ammonium induced sediment phosphorus release.

S4. Drivers of diversity patterns in microalgal assemblages

S4-O When the algae go marching in. An overview of microalgal diversity patterns at different spatial scales.

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Since the seminal paper “The Paradox of the Plankton” by G.E. Hutchinson published in 1961, the scientific literature has offered many examples of investigations aimed at clarifying the factors contributing to the amazing microalgal diversity. The richness of microalgae (phytoplankton and phytobenthos) is widely recognized to depend on species-specific competition skills (e.g. allelopathy, abilities in resource acquisition and in avoiding predation) in a fast-changing environment characterized by the turbulent mixing of water masses. This vision considers the single water body as the arena where diversity is built. More recently, this vision was expanded by considering the role of immigration through passive dispersal as an important factor shaping microalgal diversity in freshwater ecosystems. Several studies have been published in the last several years showing the importance of landscape structure, further to local environmental factors, in explaining microalgal structure and patterns in inland waters. This new approach is resulting in the idea that communities in different water bodies are not isolated and self-driven, but they are part of a larger metacommunity and are continuously interacting via dispersal mechanisms. Several conceptual models, developed in the frame of community ecology, have been recently applied to try to better understand microalgal diversity patterns within and among water bodies at different geographical scales. This presentation is intended as an introduction to the Special Session “Drivers of Diversity Patterns in Microalgal Assemblages”: a step ahead in the attempt of unravelling the relative role of local and regional processes in shaping the microalgal diversity and species distribution patterns, which may contribute to the monitoring of local and regional changes in biodiversity, and is essential for the development of sound conservation strategies among them to understand invasion patterns and mechanisms.

S4-O Long-term response of phytoplankton community to change in limnological condition in a large tropical reservoir, Southern China.

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Dashahe reservoir is a large tropic waterbody for drinking water supplying and suffered a lasting cyanobacterial bloom since 2006. Since the first blooming, the local government conducted an intensive watershed management to improve water quality, resulting in shift in limnological regime. To demonstrating the response of phytoplankton community to such change, here, we presented a long-term ecological and limnological observation from 2008 to 2017. The hydrodynamics indicated by water retention time, water level, water temperature and precipitation oscillated slightly, but nutrient level and light condition largely changed. Chlorophyll-a concentration (Chl*a*) increased from 12 μg/L in 2008 to highest concentration, 35 μg/L in 2011, then decreased to 15 μg/L in 2017 and its 99% variation was explained by nutrient variation. *Microcystis, Dolichospermum* and *Cylindrospermopsis* bloomed together and dominated in dry seasons. In long-trend, the abundance of *Microcystis* increased from 0.5×10^7 cells/L in 2008 to 1.6×10^7 cells/L in 2011 then maintained at 1.4-1.5$\times10^7$cells/L; the abundance of *Dolichospermum* increased from 0 in 2008 to 8×10^6cells/L in 2011 then continually decreased to 1×10^6 cells/L in 2014; the abundance of *Cylindrospermopsis* continually increased from 0 in 2008 to 1×10^7cells/L in 2014. Time-series analysis showed the main limnological variable explaining the residual was different for the three dominant genera, i.e., water temperature was selected for *Microcystis* abundance; total nitrogen, ammonium and transparency for *Dolichospermum* abundance; and total nitrogen and nitrate for *Cylindrospermopsis* abundance. In conclusion, phytoplankton biomass is able to rapidly respond to the decrease of total phosphorus, but the response of each species varied. *Cylindrospermopsis* was insensitive to decrease in phosphorus concentration.

S4-O Phytoplankton functional composition shows increasing seasonal variability in a large shallow lake after a eutrophic past.

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The global problem of eutrophication has some easily recognizable and potentially harmful effects on aquatic habitats, but our knowledge on the underlying associated changes in ecosystem functioning is rather limited. Relevant studies suggest that seasonal variability in phytoplankton composition shows an increase as eutrophication progresses. The aim of the present study was to test this hypothesis through the assessment of long-term changes in the functional diversity and composition of phytoplankton in the large shallow Lake Balaton situated in Central Europe with a history of dramatic changes in trophic state. Our results have shown that the maximum range of compositional variability has a strong negative correlation with summer biomass maxima, on the other hand, average seasonal variability measured as temporal beta diversity follows a gradually increasing trend throughout the years from the period of early eutrophication to the recent period of reoligotrophication. This enhanced variability in phytoplankton succession implies that all the ecosystem processes connected to the phytoplankton follow more complex seasonal dynamics. A further analysis of background variables suggests that the observed tendency is also related to long-term changes in water temperature and depth, which urges more in-depth research efforts to understand the impact of climate change on aquatic systems in the temperate zone.

S4-O Structure of phytoplankton communities based on succession rate indices and functional groups in a temperate river of South Korea over 24 years (1993-2016).

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Freshwater phytoplankton communities have habitat preferences, which make species who share the similar habitat template assemble. To investigate patterns in the succession structure and habitat condition that correspond to significant environmental changes, succession rate indices and functional group approach were applied to long-term data collected biweekly from 1993 to 2016 except 2002 in the lower Nakdong River in South Korea. The calculated succession rate values and assigned functional groups were compared using a nonparametric 1-way analysis of variance. The dynamics of succession rate indices were mainly classified into two groups: Apr. - Oct (higher) and Nov. - March (lower). Based on the succession rate indices, phytoplankton structures should have changed in summer but it was observed that group M consistently dominated in the summer from 1993 to 2001 and after 2012. The mainly changing period in terms of functional groups were between April and May from D to P, J or, K. Use of succession rate indices allowed us to identify the periods of highly change, but the environment and the functional groups would not abruptly change. Although drastic changes in algal abundance can results in the higher rates of changes in the phytoplankton communities, competitive or well-adapted populations of phytoplankton are seems to remain the predominance when their preferred habitat is maintained.

S4-P Characteristics of phytoplankton community structure and functional groups dynamic in an estuarine reservoir, China.

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Phytoplankton communities control crucial ecosystem processes in nutrient cycling and pollutant decomposition, acting as primary productivity. Overgrowing of phytoplankton may lead to algae blooms, threating water quality. This estuarine reservoir, an estuary reservoir on the Yangtze River and a drinking water source, is facing such a problem and the factors driving changes in phytoplankton composition and distribution have not been well understood so far. To facilitate the understanding of this problem, we collected surface water samples from January 2014 to December 2014 monthly at 12 sampling sites, analyzed the dynamic of phytoplankton communities and functional groups, and identified driving factors that govern phytoplankton successions. A total of 205 species classified into 8 majors taxonomic were identified. *Cyclotella meneghiniona, Melosira varians, Melosira granalata, Cryptomonas ovata* and *Chlorella vulgaris* were the species dominating at least one season. The long stratification period and high nutrient concentration result in high Chlorophyll a (45.6±22.05μg L^{-1}) during summer, and mass algae growth also led to nutrient (NO^{3-}, PO_4^{3-}) decreases during this period. The reservoir suggested no obvious P or N limitation in this study period. We observed that temperature, nutrient concentrations and light availability (characterized as Zeu/Zmix ratio) are critical in selecting functional groups and driving phytoplankton succession. *Cryptomonas* (Group Y), *Cyclotella* and *Asterinella* (Group C) had a rapid growth rate dominantly at the end autumn and winter favoured by low light and high turbidity. *Melosira* (Group P) dominated the strong stratification period with a continuous mixed layer, stable water-column and high temperature. These results highlight that the functional groups explained the water body well and showed a good ecological state in this reservoir based on the Q index (Q average=4.0). This work also highlights that mixing regime, temperature and nutrient availability were the driving factors that dominate phytoplankton dynamics. This is the first application of the functional group approach to estuarine reservoir.

S5. Ecological impacts of water-level fluctuations (WLF)

S5-O Hymo pressures and their effects on European lakes and reservoirs:How are they assessed and evaluated? *Sandra Poikane*

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Hydromorphological (HyMo) pressures are the second most commonly occurring pressure on surface waters in Europe, affecting 38% of all lakes (by lake area; 22% by number of water bodies). In several countries, proportion affected by HyMo pressures is higher i.e. 94% in the Netherlands and 69% in Sweden (by lake area).
One hundred and two biological lake assessment methods have been intercalibrated and included in MS monitoring tool-kits, including phytoplankton (26), macrophyte (22), phytobenthos (12), benthic invertebrate (19) and fish-based (23) assessment systems. In theory, the biological classification methods should integrate the effects of all relevant pressures. However, most of lake assessment methods focus on eutrophication (95 methods aim to assess eutrophication). In most cases, the relationships between nutrients and biological response are well documented (77 methods relationship with TP has been established)
Member States report that hydromorphological pressures are addressed by at least one biological quality element in 64% of the countries. However, only eight biological assessment systems (six countries) show evidence addressing hymo pressures: five systems using benthic invertebrates, two–fish fauna, one – macrophytes. Pressure-response relationship were developed with various HyMo indices, with explained variance ranging from 11% to 80%. For this purpose, eight different HyMo metrics were used: two of them are simple indices (winter drawdown and shore alteration %) while others are more complex indices including land-use, water level alterations, shore structure, natural riparian vegetation, shore alterations, shore erosion.
In summary, there is not much evidence that the biological methods currently in use reliably pick up the effects of hydromorphological alterations. To be sure that hydromorphological pressures and their effects do not remain undetected, it is therefore very important (1) to use HyMo classification methods alongside the biological methods; (2) to develop biological classification methods
responding specifically to hydromorphological pressures.

S5-O Ecological impacts of water-level fluctuations in reservoirs in Czechia. *J. Kubečka, M. Čtvrtlíková, J. Hejzlar, T. Jůza, T. Mrkvička, M. Vašek, V. Draštík, M. Říha, J. Peterka, P. Blabolil, M. Čech, M. Frouzova J., Matěna, J., Muška, M., Prchalová M., Šmejkal, Tušer, M., I. Vejříková, L. Vejřík*

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The water levels (WL) of the reservoirs fluctuate with the rivers discharge and operational needs. This contribution reviews the best described examples with limnological consequences. Yearly difference of water levels higher that the average transparency is sufficient to exterminate typical band of submerged macrovegetation and to cause very impoverished and unstructured littoral. Only few water supply reservoirs with higher transparency and less pronounced WL fluctuation (WLF) developed this vegetation and its extent can span most of the reservoir shoreline and reach high level of diversity and structural complexity. WLF can support pelagic phytoplankton production by limiting competing macrophytes and immobilizing the nutrients deposited in the tributary zone.

Regular daily WLF of several tenth of centimeters in hydropower peaks can terminate

successful reproduction of phytolitophilous cyprinids, which dominate otherwise fish communities in reservoirs, and cause the shift to percid fish dominance. In this respect, WLF is used as biomanipulative measure to influence the pelagic food web. WLF signal of can be found in recruitment success of common bream where the WL drop of some 30 cm can eliminate the cohort. The presence of macrophytes in the reservoirs with less WLF supports the presence of phytophylic fish and has quite important influence on fish behavior. Absence of macrophytes causes the fish to be much more active and less territorial and shifts the production from the littoral to the pelagial. Consequently, it is one of the main ecological factors forming reservoir biota. Read more: https://www.macfish.net/

S5-O Impoundment intensity determines temporal patterns of hydrological fluctuation, carbon cycling and algal succession in a dammed lake of Southwest China.

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Hydrological control of lakes has been increasingly practiced in many parts of the world, however, long-term ecological impact of hydrological regulation and their dependence on lake impoundment intensity has been rarely examined. We combined surface sediments with well-dated sediment core analyses to quantify the limnological changes over the last two centuries for a shallow lake, which was dammed in 1957 and reinforced during 1987-1990, respectively. The inferred water depth increased from 6.2±0.9 m to 8.7±1.7 m after dam construction and further to 13.6±2.6 m after dam enforcement, resulting in a significant increase in the magnitude of water level fluctuation (WFL). Accordingly, bulk sediment C/N ratio and total carbon content spiked around 1957 and 1990, respectively, reflecting large input of terrestrial sources. While there was a significant increase in sediment total nitrogen (TN) and algal production since 1990, the accumulation rate of TN and total organic carbon displayed an accelerating drop since 1957, reflecting a diluting effect derived from expanding water storage. With a consistent loss of littoral zone over time, a gradual decrease in benthic diatoms and an abrupt depletion of carbon isotopic signal after 1990 suggested a shift of food web carbon transfer. Hydro-morphological variables were found to exert stronger impact on diatom communities during the damming stage than the pre-disturbance and reinforcement stages, with an increasing interplay with nutrient and climate variables over time. There existed a significant shift of diatom composition in ~1960, meanwhile, diatom species richness and community dissimilarity showed a significant decrease when water depth was raised to above ~10 m or the magnitude of WFL was above ~2 m. Thus, our sediment surveys provide evidence on the significant impact of lake regulation on hydro-morphology, nutrient cycling and ecosystem shift over time, as well as its stronger interaction with other forcing with increased impoundment intensity.

S5-O Effect of water level changes on variations of *Anabaena* and its heterocyst in Poyang Lake.

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As one of the only two lakes that retain its free connection with the Yangtze River, Poyang Lake exhibits large annual and interannual water level and nutrient fluctuations. The biomass and heterocyst frequency of *Anabaena* and the corresponding environmental parameters were weekly or bi-weekly monitored during the period June to November in 2013 and 2014. *Anabaena* was observed throughout the year, and the average relative biomass of *Anabaena* in the study period was over 40%, being most abundant in summer. *Anabaena* formed heterocyst and was well-adapted to the low nitrogen concentrations in the high water level phase in Poyang Lake. Results indicated that physical and chemical variables responded to water level changes and coincided with the seasonal variation, finally leading to variations of *Anabaena* and its heterocysts.

S5-O Impact of the terrestrial subsidies on pan dynamics in Hwange National Park and its periphery, Zimbabwe.

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Aquatic ecosystems have an important role in the savanna ecosystem as a source of drinking water. However, wildlife and domestic fauna may impact the dynamics of these ecosystems with subsidies and bioturbation of the water. Therefore, with inputs of organic matter and nutrients from urine and faeces, terrestrial fauna may strongly modify the trophic status and the dynamics of these aquatic ecosystems. To study the dynamics of these aquatic ecosystems and their links with terrestrial ecosystems, we monitored 30 pans and dams in Hwange National Park and its periphery (communal zone and the forestry), Zimbabwe. Dams and part of the pans are fuelled by rain water and are temporary; the rest are actively replenished by pumps and permanent. We also estimated terrestrial subsidies during the dry season and measured nutrient content of fauna faeces. In addition, we measured in 10 pans the major nutrient concentrations from the sediment to 50 m from the pans. The survey suggests different modes of functioning of the pans, which might change according to the season in the relation to faunal activities. Data analysis shows that variability among pans and dams is best explained by water chemistry and phytoplankton and macrophytes abundance. Water chemistry is highly dependent on soil properties, evaporation and water run-off. Terrestrial fauna, in particular elephants, seem to play an important role in controlling the presence of primary producers through their impact on turbidity and nutrient concentrations. We show that the terrestrial subsidies are mostly due to elephants, which may bring up to 8.65 g C/m².day, 0.25 g N/m².day and 0.06 g P/m².day during the dry season and there is a strong nutrient gradient from the sediment to the bush presumably due to these subsidies. These results pose the question of feedbacks of water quality on fauna distribution among drinking pans.

S5-O Indicators of water-level fluctuations in the littoral of natural and artificial lakes: from molecules to assemblage features.

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To protect the world's freshwater resources, human and biodiversity perspectives on water security need to be jointly considered. Preserving ecological functionality and biological complexity of freshwater ecosystems is the only way to safeguard many valuable services and benefits to society. Freshwater littoral zones are heterogeneous environments with high physical complexity and connectivity, nutrient cycling, biodiversity, and productivity. They are amongst the

most ecologically valuable, but also most threatened, systems worldwide. Water-Level Fluctuations (WLF) are becoming one of the globally increasingly pervasive threats to the ecological integrity of lakes, and they have an overriding effect on lake ecosystem health. WLF effects on ecosystems are greatest in shallow water and littoral areas, where even small draw-downs can result in the conversion of large submerged areas in exposed habitats. Some organisms appear to be real WLF specialists, as for example the benthic filamentous red alga Bangia atropurpurea, and the Lake Constance Forget-me-not (Myosotis rehsteineri). Littoral zones with artificially stabilized water levels may have lower species richness and higher cover of invasive plants than those with more natural hydrology. In the depth distribution of cyanobacteria and algae, three zones are often recognized with the eulittoral supralittoral being disturbed by WLF and increasingly affected by nonnative and invasive algae, and the mid-depth and deep zone characterized by environmental stability and occurrence of a distinct and unique subset of lake benthic algae. The present contribution will review the literature on benthic indicators of WLF (with a focus on the last ten years), and discuss case studies and examples from the own and published research.

S5-O Impacts of macrophyte beds on nutrient dynamics and phytoplankton biomass during water level fluctuations. *Jing Lu*

Australian Rivers Institute/Griffith University, Australia

Macrophytes play a key role in reducing water column nutrients and controlling phytoplankton blooms in aquatic ecosystems. However, macrophytes can become desiccated after severe water level drawdown, subsequently releasing nutrients after rewetting. This study compared the role of macrophytes as a nutrient sink versus a source during water level fluctuations (WLFs), and its implications for phytoplankton blooms. My study showed that macrophyte beds shifted from a nutrient sink to a source after desiccation followed by rewetting, resulting in increased phytoplankton biomass. This occurred when minimum soil moisture content was reached in the macrophyte bed after a 10-week desiccation period. Sediment desiccation changed the fate of macrophyte-derived nitrogen (N) after rewetting, causes more water quality deterioration. This was further exacerbated by the presence of litter, especially in the case of an invasive submerged species. Regrowth of macrophytes after rewetting reduced nutrient release to the water column and sediments compared to no regrowth. Overall, macrophytes had a more significant impact on water column phosphorus (P) than N, compared to bare sediments, after drying then rewetting. This changed the water column N:P ratio with potential flow-on effects to phytoplankton biomass. These findings indicate that effective water level management is essential to protect macrophytes and reduce the risk of phytoplankton blooms during WLFs.

S5-O Diatom-based models for inferring water level change in peatlands, northeast China. *Xu Chen[1], Suzanne McGowan[2], Zhaojun Bu[3], Xiangdong Yang[4]*

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Peatlands are very vulnerable ecosystems and sensitive to changes in the ground water table. As monitoring data are limited and in order to reveal past water level change, 45 surface samples were collected from five peatlands (northeast China) in order to develop a diatom-water level

transfer function. Diatom assemblages were dominated by Enotia, Pinnularia and Chamaepinnularia genera, and displayed a clear variation along the water table gradient. Canonical correspondence analysis indicated that diatom assemblages were significantly correlated with DWT, ORP, NO^{3-} and Na. DWT was the most important and significant variable in explaining the diatom distributions, independently accounting for 13.5% variance in diatom data. A diatom-DWT transfer function was established using weighted averaging (WA) with inverse deshrinking. Compared with other multi-proxy transfer functions (e.g. testate amoebae, bryophytes, vascular plants) for reconstructing peatland water level, this model had low predictive error (root mean squared error of prediction; RMSEPjack=3.70) and a high coefficient of prediction (R2-jack=0.85). The diatom-DWT model developed in peatlands of Northeast China provides a new method for reconstructing historical changes in water table in peatlands, and it can be an indication of changes in paleohydrological condition.

S5-O Response of lakes undergoing water level fluctuations to climate change - a lesson learned from Lake Kinneret, Israel. *Avital Gasith*

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Imbalance between the yearly inputs and outputs of water causes seasonal fluctuation of water level in lacustrine systems. This phenomenon is characteristic of lakes in mediterranean-climate regions where the rainfall pattern is distinctly seasonal. Lake level fluctuations enforce a change in the position and structure of littoral zones, and consequently modify the availability of the littoral zone resources, thus modifying ecological interactions. In Lake Kinneret lowering of the lake level exposes beach areas, reduces rocky littoral habitats and increases sandy ones, and vice versa when the lake level rises. Positive or negative response of littoral zone communities varies with changes in the availability of local resources. Consecutive droughts are followed by low lake levels, which limit reproduction success of fish and reduce establishment of invertebrates requiring rocky habitats, as well as communities favoring vegetated environments. On the other hand, drawdown of the lake level facilitates massive establishment of shore vegetation in the exposed shores. When followed by a rise of the lake level (rainy years) the vegetation is inundated, providing abundant vegetated habitats, likewise, rocky habitat are more plentiful. Under these conditions, littoral communities requiring these resources, flourish. In the past 50 years evidence of impact of climate change on rainfall distribution in the eastern Mediterranean, accumulate. This is supported by a greater frequency of drought years, shorter and more intensive rainfall events and shorter winter period. The impact of these environmental changes on the littoral zone structure and thus on its function in Lake Kinneret is expected to increase, and to have a cascading impact on stability and integrity of the ecosystem. Despite efforts to limit climate change, its impacts still continue to threaten terrestrial and aquatic ecosystems globally; seasonal water imbalance in lakes is expected to become a more widespread phenomenon.

S5-O Water level fluctuation requirement of hygrophytes in Yangtze Floodplain Lakes. *Hong-Zhu Wang, Xue-Qin Liu, Sai-Bo Yuan, Zhen-Dong Yang*

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Water level management is of great importance in terms of conserving and rehabilitating wetland plants, but water level fluctuation (WLF) requirements of hygrophytes have not been well studied. In this study, we first investigated the hygrophyte community and its environments in 13 Yangtze floodplain lakes during 2011-2015, and carried out simulation experiments on the dominant species, Carex cinerascens, in 2015. Then, we classify hygrophytes into

water-level-limited guilds according to their biological traits related to water level fluctuations. Finally, we establish an integrated WLF requirement model for Carex guild, and assess the WLF requirements of other guilds based on field investigations. A total of 163 hygrophyte species were identified and these plants are divided into 11 water-level-limited guilds. With regard to WLF requirements, Carex guild is well developed in lakes with intermittent water level fluctuations. The Carex rhizomes can not emerge underwater or water-saturated condition. Its growth is prohibited when inundation depth is higher than plant height and rate of water level change exceeds 1.2 cm/d. The timing of habitat inundation is suggested to be after May when the plant mature. The timing of rhizome emergence in the second growing season is determined by timing of habitat exposure, and the optimum timing is October. We finally establish an integrated WLF requirement model of Carex guild in Yangtze floodplain lakes by combining requirements of each life history stage. It is the first time for WLF requirement model to be proposed for hygrophytes in lakes. Moreover, we present a methodology for assessment of WLF requirements of hygrophytes which can be widely used in riverine lakes as well as other wetlands. Our results provide important implications for water level management regarding the conservation and rehabilitation of wetland plants.

S5-O Effect of water level fluctuations on stratification of Lake Shira (South Siberia): from modern observations to paleo-reconstruction.

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It is well-known that lakes may change their mixing regimes from holomictic to meromictic in response to level increase, and vice versa. Saline Lake Shira (South Siberia, Russia) was meromictic through the observation period 2002-2015. During the under-ice periods of 2015 and 2016, complete mixing of the water column was recorded, and hydrogen sulphide temporarily disappeared from the lake; i.e. in those years the lake turned to holomixis. A sharp increase in chlorophyll a, organic carbon, zooplankton, and phytoflagellates was observed in the lake, which was probably due to the release of nutrients from the monimolimnion. Purple sulfur bacteria completely disappeared from the lake after the first mixing in 2015, and did not reappear despite the restoration of meromixis in 2017. It was shown that in previous years a significant contribution to the maintenance of meromixis was made by an additional influx of fresh water, which caused a rise in the lake level in the period 2002-2007. During the period of constant level of 2008-2018 the stratification was weak and sensitive to weather impact. The main cause of holomixis in 2015 was the weakening of the salinity gradient due to strong wind impact and early ice retreat in the spring of 2014. From bottom sediments we estimated the switches between meromictic and holomictic conditions caused by climate-induced fluctuations of water level. The fossil pigments of phototrophic sulfur bacteria were considered as a proxy of anoxia in water column. Thus, we identified a relationship between the stratification regime of the lake and the change in its level, which provides valuable information both for reconstruction of the climate humidity in this region of Southern Siberia.

S5-P Influence of dam construction on the diazotrophic function and community composition in the riparian sediments.

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Dam construction has significantly influenced riparian ecological functions and environmental conditions within the reservoir region, yet the impact of such disturbances on diazotrophic populations is unknown. Here we examined the diazotrophic activity and community assemblages in the riparian zones of six dam-formed reservoirs located in the Lancang River, China. The sampling sediments were from dam-affected and control sites in each reservoir, which represent with and without direct dam effects, respectively. The abundance and community composition of diazotroph were determined by *nifH* gene. Our results indicated that the higher activity and copy numbers of diazotroph were found in the dam-affected sediment than the control sediment. The sediment of the dam-affected sites also displays the higher α-diversity and the significantly different community structure of diazotroph, compared with those of the controlled sediment. Deterministic processes significantly dominated the assemblage of the diazotrophic community and further increased its importance in the affected sediment, which should be correlated with the environmental homogeneity. Additionally, the dominate environment driver for community structure and the relative abundance of diazotrophic taxa showed the corresponding changes in the dam-affected sediment. These results suggest that damming caused a pronounced influence in diazotrophic populations in the riparian sediment of the reservoirs, and this significant impact may provide a more suitable condition for diazotrophic ecological function.

S6. Effects of plankton dynamics on methane fluxes and emissions from inland waters

S6-O Potential contribution of zooplankton to the methane paradox in a meromictic alpine lake.

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The mechanism behind elevated methane (CH_4) concentrations in the oxic waters of lakes and the ocean, also referred to as methane paradox, remains enigmatic. Hypotheses include CH_4 production in association to plankton metabolism, or lateral transport from shallow sediments. Here, we combined 1) monitoring of plankton and water column physical characteristics, 2) time-series measurements of the concentration and isotopic composition of CH_4, as well as 3) plankton incubation experiments, in order to shed light on the source of CH_4 in oxic waters of the meromictic Lake Cadagno (Switzerland). Our data reveal that CH_4 is produced in situ in the well-oxygenated lake waters. The epilimnetic maximum (between 5 and 12 µmol L^{-1}), associated with a strong density gradient, persisted through the productive season (June to September), but was absent in fall and winter. The epilimnetic concentrations were three to five times higher than inshore, and CH_4 displayed a C isotopic signature that differed from benthic CH_4 sources. Together with water isotope measurements, used to trace potential intrusions, these data argue against contribution of lateral transport to the methane paradox. Diurnal monitoring showed that the epilimnetic CH_4 maximum is a stable feature of the water column that is independent of the daily photosynthetic activity. Yet, analysis of the zooplankton distribution revealed the accumulation of nauplii and zooplankton-related detritus at the depth of the CH_4 maximum. Laboratory experiments with *Daphnia*, as well as adult and juvenile copepods, showed CH_4 production of 0.5 to 0.7 nmol per organism and per day by moulting copepods. While at this point we can only speculate that methanogens from the gut tracks of nauplii are released to the environment with moults, we postulate that the methanogenetic decomposition of zooplankton-related detritus explains the accumulation of methane in oxic waters and contributes to the methane paradox in Lake Cadagno.

S6-O Carbon dioxide ad a main driver of oxic water column methangenesis in lakes.

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Mounting evidences suggest that the nearly ubiquitous methane (CH_4) oversaturation in the surface water of lakes is sustained, at least partly, by CH_4 produced in the oxic layers. Although its existence is rapidly gaining acceptance, the magnitude and environmental regulation of oxic CH_4 production has remained largely equivocal, yet existing evidence has suggested a link to photosynthesis. Here we show, using mass balance in the stratified surface layers of five northern lakes that oxic water CH_4 production (0.04 - 0.63 μmol L^{-1} d^{-1}) accounts for 12 - 65% of summer diffusive CH_4 fluxes from all, but one lake where water column derived CH_4 nearly fully supported the surface emissions. Further, multiple intensive 24-hour samplings in two limnologically contrasting systems showed strong diurnal variability in pelagic CH_4 production, with peaks in the afternoon and substantially low or complete cessation in dark, corroborating the strong functional links between oxic water methanogenesis and diel changes in phytoplankton photosynthesis. However, we found a stronger coupling between pelagic CH_4 production and carbon dioxide (CO_2) concentrations across our study lakes and argue that CO_2 supersaturation can influence oxic water methanogenesis by stimulating phytoplankton productivity in nutrient-poor lakes. Our study shows that oligo-mesotrophic lakes in the remote northern landscapes can still be substantial contributors of atmospheric CH_4 and suggests that further increase in CO_2 concentration resulting from lake browning and direct soil CO_2 input may have unforeseen consequences on aquatic CH_4 production.

S6-O The use of methane – derived-carbon in planktonic food webs depends on the lake trophic status.

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Methane serves as carbon source for pelagic food webs. However, the environmental controls of this alternative carbon source in lakes with different mixing regimes, trophic status, and plankton community structure are still constrained. We investigated seven lakes varying in trophy, thermal and mixing regime to evaluate differences in isotopic composition of zooplankton in relation to vertical distribution of methane oxidizing bacteria (MOB), phytoplankton and physico-chemical gradients. Together with methane production and its distribution in the water column we present the isotopic analyses of zooplankton originating from epi-, meta- and hypolimnion of studied lakes to establish what specific conditions promote usage of CH_4 as a source of carbon for plankton. The abundance of MOB, a potential food for zooplankton is regulated by the availability and concentration of dissolved CH_4 and O_2 at the sediment interface and in the water column. In consequence, the MOB were found to be most abundant at the oxycline in lakes of the highest trophy with oxygen deficits in hypolimnion. Our preliminary

results also show that the proportion of methane derived carbon in the planktonic biomass is the result of interaction between its vertical gradient and lake trophy.

S6-O Towards a deep analysis of carbon greenhouse gas dynamics in a eutrophic lake.

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Small and shallow lakes emit important amounts of greenhouse gases (GHG) to the atmosphere, highly impacting the global carbon budget. We conducted a full spatial characterization of CH_4 and CO_2 dynamics in a small (24 ha) temperate eutrophic lake (L. Dagow, Germany) with the objective to identify the total amount of carbon emitted and to identify drivers for the gas distribution. Following a regular grid over the lake's surface we measured emission rates to the atmosphere, highly resolved concentration profiles along the water column, bubble release from sediments accompanied by micrometeorological and water quality analysis at up to 40 locations along the lake. We used a combination of high resolution measurement techniques, including: (i) a new generation gas analyzer using infrared spectroscopy coupled to floating flux chambers, (ii) bubble traps for gas coming out of sediments, and (iii) a new generation of gas analyzer coupled to a degassing membrane operated in continuous mode for measuring dissolved CH_4 and CO_2 concentration in the water column. The study is associated with a eddy covarianz system positioned in the center of the lake. Altogether, the study provided a full picture of the CH_4 and CO_2 budget, location and dependence on micrometeorological conditions like wind strength. We identified three main type of zones within the lake: (i) the central and deeper zone, as the most productive in terms of carbon degradation, emitting 77 % of the total CH_4 by the lake, and 83 % of the total CO_2 releasedby the lake, (ii) littoral zones covered with macrophytes, which are less productive contributing with 21% of the total CH_4 emitted by the lake and 15% of the total CO_2 emitted by the lake, and (iii) littoral zones without macrophytes receiving carbon mainly from run-off water, which are the less productive zones with almost neglectable CH_4 and CO_2 emissions (2 and 1% respectively of the total gas emitted by the lake). Based on a solid data-set, we could demonstrate dependencies of carbon GHGs emission on depths, oxygen availability, carbon source and micrometeorological conditions as wind speed.

S6-O Methane fluxes and related ecological processes in Amazon floodplains.

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Methane and related limnological measurements were performed in three major aquatic habitats (open water, flooded forests and floating aquatic plants) of the central Amazon floodplain over a two year period. Methane evasion to the atmosphere was determined from accumulation in floating chambers, collections of bubbles in inverted funnels, and from air to water gradients in concentration combined with gas transfer velocities. During each set of diel measurements of methane, meteorological sensors, high-resolution thermistors and dissolved oxygen sensors were deployed. Chlorophyll, total dissolved nitrogen and phosphorus, and particulate and dissolved

carbon were assayed. Dissolved CH_4 concentrations varied from 0.001 μM to 468 μM; fluxes varied from 0.15 to 10,290 μmol m^{-2} hr^{-1}. This very wide range of concentrations and fluxes results from large variations in water level (1 to 12 m), depth and frequency of vertical mixing, wind-driven and convection-caused differences in gas exchange coefficients, seasonal inputs of organic matter from plankton and floating plants, methane oxidation and dissolved oxygen dynamics.

S6-O Spatial-temporal patterns of methane dynamics in Lake Taihu.

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Lakes have been recognized as an important source of atmospheric methane (CH_4), the CH_4 emission budgets will be inaccurate if spatial and seasonal variabilities are not considered, especially for large and shallow lakes. Here, CH_4 concentrations in sediment and lake water and CH_4 fluxes from sediment were analysed in open water areas of Lake Taihu, the third largest freshwater lake in China. The results showed that Lake Taihu was a source of CH_4 throughout the year. The observed CH_4 concentrations were higher in the northwestern and southeastern areas of Lake Taihu, especially in East Taihu and Zhushan Bay, and lowest in the central area. This spatial heterogeneity was mainly related to organic matter content, plant characteristic, deposition rate and sediment feature. The CH_4 concentrations and fluxes were much higher in summer, and no significant difference existed among other seasons. This research suggests that the study of CH_4 dynamics in shallow lakes should give major consideration to areas with different ecotypes and depositional conditions. Furthermore, a high sampling frequency during periods of high temperature is necessary to avoid temporal bias.

S8. Freshwater mussels: ecosystem disruptors or ecosystem restorers?

S8-O Ecosystem responses to dreissenid mussels in polymictic lakes 25 years post-invasion.

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Documented ecosystem effects of invasive zebra mussels (*Dreissena polymorpha*) include increases in water clarity, declines in phytoplankton and zooplankton biomass, increases in many benthic invertebrates and increases in the relative abundance of benthivorous fish. These observed effects may or may not remain important over decadal time scales as the invaded ecosystems adapt to mussels. Further, it is not known if the replacement of zebra mussels by another invasive, the congeneric quagga mussel (d. *bugensis*), will modify the observed effects. We investigate these questions using 40-year data sets on various ecosystem components available from four shallow lakes that were invaded by zebra mussels in the early 1990s (Naroch, Myastro, Batorino in Belarus and Oneida in USA); one of which (Oneida) also has had quagga mussels since 2006. The predicted ecosystem effects of zebra mussels were evident in all four lakes, and these effects persisted for 25 years. However, there are signs of ecosystem resilience -a tendency for a return

towards pre-dreissenid conditions (higher phytoplankton and zooplankton, lower benthos, less benthivorous fish) in the most recent decade in the three lakes with only zebra mussels. In Oneida Lake, the initial effects of zebra mussels increased in magnitude after the arrival of quagga mussels. This suggests that the effects of zebra mussels do diminish over time as mussels becomes integrated into the invaded ecosystem. However, quagga mussels, although similar to zebra mussels, have additional ecosystem effects, in particular stronger effects in early spring and late fall as quagga mussels are more active at colder temperatures than zebra mussels.

S8-O Comparison of ecological status and water quality between the lakes with and without zebra mussels.

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Zebra mussels (*Dreissena polymorpha Pallas*) are regarded as ecosystem engineers owing to their great impact on aquatic community structure and environmental conditions, and as a result on ecological status of lakes. We compared ecological water quality between five Belarussian lakes. Lake Obsterno and heated Lake Lukmlskoe are inhabited by zebra mussels while in Lake Gorushka, Lake Nobisto and, Lake Beloe, they are absent. In addition, we compared ecological water quality of Lake Obsterno before zebra mussel invasion with that after its settlement in the lake. The water quality was assessed according to physical, chemical and biotic parameters. For assessments of biotic indices, we used traits of phytoplankton and cladoceran communities based on the EU Water Frame Directive requirements and saprobity index calculated by the Pantle – Buck method in Sladechek's modification. High transparency is frequently associated with high water quality. However, our results showed that increase of transparency in the lakes after zebra mussel introduction was not in accordance with amelioration of water quality estimates based on biotic indices. We found that estimates based on transparency values in the lakes with and without zebra mussels did not correspond to those measured on the basis on saprobity (mismatch above 70%) and other biotic indices (above 50%). Multiple assessments of water quality evidenced that introduction of zebra mussels did not improve ecological water quality although it reduces phytoplankton biomass, thus increasing transparency.

S8-O Effects of zebra mussels on cladoceran communities under different trophic conditions.

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The purpose of this study was to determine how zebra mussels affected cladoceran

community structure under eutrophic and mesotrophic conditions. We conducted a mesocosm study where we manipulated the presence of zebra mussels and the presence of large bodied *Daphnia* (*Daphnia* magna and *Daphnia* pulicaria). We anticipated that small- and large-bodied cladoceran species would respond differently to changes in algal quality and quantity under the effects of zebra mussels. Indeed, large bodied *Daphnia* successfully established in the zebra mussel treatment but failed to grow in the control both in mesotrophic and eutrophic conditions whereas small-bodied cladocerans did not respond to zebra mussel introduction. We did not observe any positive significant relationships between food concentrations and cladoceran abundances. However, phosphorus content in the seston indicated that food quality for large-bodied cladocerans was below the threshold level at the beginning of the experiments. In zebra mussel treatment, $P\text{-}PO_4$ was shown to increase more abruptly than in control. We suggest that zebra mussels quickly enhanced phosphorus content in the seston due to the excretion of inorganic phosphorus, thus facilitating the development of large bodied *Daphnia* at the beginning of the experiment. In conclusion, the main driver of cladoceran species structure in lakes can be food quality in terms of C:P ratio.

S8-O Can filtering mussels improve water quality substantially in shallow lakes?

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Filtering mussels are “ecosystem engineers” that can alter the structure and function of freshwater ecosystems. However, these ecosystem changes are reported as negative for water quality (disrupting ecosystems through nutrient excretion and causing harmful algal blooms) or positive (restoring ecosystem by filtering on particles and increasing in water clarity). We conducted experiments on effects of nutrient excretion, sediment nutrient release, and filtering by Anodonta woodiana on water quality. In the nutrient excretion experiment, it was found that the mussels increased total nitrogen (TN), ammonium and total phosphorus (TP) in water column, but did not change the concentrations of soluble reactive phosphate (SRP). In the sediment nutrient release experiment using a 32P radiotracer, we found that Corbicula fluminea (instead of A. woodiana due to the small size of the tube-microcosms) accelerated P release from the sediment. In the filtering experiment that was set up simultaneously in restored clear and unrestored eutrophic sub-lakes of Huizhou West Lake with young and adult mussels of A. woodiana, we found that in clear water, the mussels increased ammonium and TP concentrations in the water column, but did not change TN, total suspended solids (TSS), or Chl *a* of phytoplankton, which indicates that the mussels did not improve the water quality in the clear water conditions. In eutrophic conditions, though the mussels did not change the concentrations of TN, they decreased the concentrations of TSS, Chl *a* and TP, which indicates that they can improve the water quality. The filtration rate of young mussels was generally higher per unit mass than that of adults and higher in spring than in summer. A mesocosm experiment found that mussels decreased TN, TP and Chl a concentrations of phytoplankton, and increased the light intensity and Chl *a* of benthic algae, thereby improving the water quality.

Our study demonstrates that filtering mussels, likely through their filtering on phytoplankton,

can improve water quality in eutrophic systems. However, mussels alone cannot improve water quality in clear water conditions, probably due to their excretion of nutrients excretion and enhanced sediment P release.

S9. Global lessons from lakes of the world

S9-O Importance of Limnological Research for a Changing World Climate. *Charles R. Goldman*

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Not since the advent of the atomic bomb has the world ecosystem including all of humanity been faced with a more serious threat to the future existence of our species. Unfortunately some people still cling to a hope that the science on climate change and global warming could all be wrong. The reality of a changing climate continues to thin their ranks but they are still supported by the enormous fossil fuel investments by industries and their political allies. Although the embers of their dying fire still glow through the media and are unlikely to be extinguished by more science or reason there is little point in wasting our energy on a vocal, fading minority and their antiscientific view of the world. Many deniers have already made a tactical retreat to admitting that warming is occurring but still claim that humans are not responsible for the Carbon Dioxide and Methane driving the process. Faced with the reality of Climate Change what can and should Limnologist do to better understand and where possible anticipate the most likely changes to our essential surface water supplies? In our recent edited book on the subject of Climate Change we found that only the New Zealand lakes, which are highly buffered by the surrounding cold marine waters, are not yet significantly warming. Our history of eutrophication research and management continues to be very relevant since we will have very limited ability to influence temperature, but improved nutrient management can still help to mitigate the negative impact of heat stimulated eutrophication. Shading by tree side ponds and streams can slightly reduce solar heating but intensive nutrient management is most likely to be the first line of defense for the unfortunate impacts of warming. Warmer water will tend to promote more cyanobacteria blooms and the associated neurotoxins they produce. If the warm Gulf Stream current continues to weaken cooling is likely to envelope northern Europe and limnologist will be faced there with anticipating the impact of the reverse of global warming. The ever increasing importance of maintaining the quality of potable surface water supplies as populations increase can scarcely be over emphasized. Fourteen million people in Japan for example depend on Lake Biwa's water and throughout the world clean drinking water availability is a serious global problem. Applicant of our knowledge to help solve current and future water problems is not only and opportunity but also the responsibility of current and future limnologists.

S9-O Lake archipelagos and climate feedback in the rapidly warming northern landscape. *Warwick F. Vincent*

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In the 19th century, Stephen Forbes referred to lakes as islets of water surrounded by land, and today when flying across northern Canada in summer, the landscape appears below as archipelagos of water-filled basins in the tundra. Several features of the Arctic and Subarctic environment contribute to this extreme abundance of lakes and ponds, including the low evaporative losses, the fast-tracking of water above the permafrost table from melting snowpack to the lakes, and the short amount of time that has been available for infilling by lake sediments since the basins were created by glacial action. Some of the densest 'lake archipelagos' are those created by thermokarst, the thawing and collapse of ice-rich permafrost. Our work on these thaw lakes and ponds in the low arctic has shown that they are strong emitters of methane and carbon dioxide to

the atmosphere. Eastern Hudson Bay is one of the fastest warming regions in the North, and the permafrost landscapes are thawing rapidly, resulting in the rapid production and expansion of thermokarst waterbodies. Molecular analysis of thaw lake microbiomes shows that they contain a diverse microbiota with a high proportion of enigmatic taxa, and a separation of community structure (viruses, bacteria, archaea and microbial eukaryotes) between organic and mineral landscape types. The communities are also functionally diverse, with methane production and consumption pathways figuring prominently, as well as phototropic communities. The latter includes harmful cyanobacterial bloom species that may rise to prominence with further warming. Comparison of thaw lake archipelagos at the ends of a 200 km north-south gradient indicates that ongoing climate change is likely to stimulate methane emissions from these abundant microbial ecosystems well into the future as a result of increased inputs from thawing permafrost, a vast and now unlocked reserve of organic carbon in the warming Earth system.

S9-O Vertical flux of organic matter to the sediments of Lake Bonney, a permanently ice-covered Antarctic lake.

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The lakes in the McMurdo Dry Valleys of Antarctica were first investigated in the early 1960's by Charles Goldman and colleagues. These lakes are unique in that they maintain a 3 to 7 m ice cover throughout the year, receive no sunlight through the polar night, do not mix to the bottom, and the food webs contain few metazoans and no fish. Phytoplankton productivity in Lake Bonney, Taylor Valley, has been measured over the ~20 m thick trophogenic zone during the austral summer since the early 1990's as part of the NSF-funded McMurdo Long-Term Ecological Research project. Despite these long-term measurements, little is known about the fate of this newly fixed organic carbon over the year. Time series sediment traps were deployed in the bottom Lake Bonney for the past decade to gain an understanding of the loss of this newly fixed organic matter to the sediments. The flux of particulate organic carbon typically peaked during the summer months reaching 23 $mgC/m^2 \cdot d$, the majority of which was less than 63 μm. This organic carbon amounted to about 1% of the total dry weight of material the traps during the summer and ranged from 5 to 16% of the total dry weight of material during other portions of the year. These results together with measurement of glacial stream flow into the lake indicate that much of the dry matter collected in the traps during the summer was derived from stream input. DNA sequence data from the trap material revealed that the relative abundance of cyanobacteria reached 40% of the total prokaryotic population sequenced. The source of these cyanobacteria, based on Bayesian source tracking results, showed that the cyanobacteria were derived from stream mats growing in the glacially fed streams entering the lake. Collectively, our results indicate that stream derived cellular material contributes significantly to the flux of particulate organic carbon in Lake Bonney. Sequence data from eukaryotes collected in the sediment traps were closely related to the phytoplankton in the overlying water column.

S9-O The Influence of Climate and Winter Dynamics on Lake Ecological Structure: Insights from Castle Lake, the America's Oldest Mountain Lakes Program.

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In recent years, alterations to the hydroclimate of the mountains of the Western United States have been quantified including changes in the timing, type (rain versus snow), and intensity of precipitation, development of "snow droughts" during winter season, and increases in air and surface water temperatures. Despite these observations there has been little study on the influence of hydroclimate and winter dynamics to the ecological conditions (e.g. nutrient chemical species, primary productivity, algal composition, zooplankton composition and biomass, fish energy flow, and food web trophic structure) of small lakes. In this study, we summarize the influence of climate and winter dynamics to the ecology of subalpine, Castle Lake with observations from other small, mountain lakes. Ice-cover and ice-free primary productivity are positively correlated (r^2= 0.48, p<.001) with significantly lower rates during ice-cover periods (p<0.001). A subset of these lakes, show an increase in zooplankton abundance and phytoplankton biovolume during the ice-free season compared to ice-on periods. Phytoplankton compositions varied across lakes with Chlorophyceae, Euglenophyceae, and Bacillariophyceae dominating in ice-free periods and Bacillariophyceae dominating in ice-cover periods. Zooplankton composition also varied across lakes with cladocerans and cyclopoid and calanoid copepods dominating in ice-free periods and cyclopoid and calanoid copepods dominating in ice-cover periods. The production in the littoral zone of Castle Lake is positively related to ice out date, where early ice-outs result in higher levels of littoral production. An inverse relationship was observed for pelagic secondary production, where early ice-outs resulted in lower amounts of production. Fish (brook trout) energetics determined from stable isotope were independent of habitat secondary productivity, but were strongly correlated with littoral zone water temperatures. Compound specific stable isotopes suggest that the amount of autochthonous versus allochthonous production was similar across years with highly variable ice out periods. We suggest there are complex, divergent and highly variable ecological dynamics during winter, ice on versus summer ice free periods. In addition, the flow of energy through the food web to fish consumers is dictated by the winter, ice on period which may change in the Western United States depending on the location (latitude and elevation) of the lake.

S9-O Water stracture and strategy for restoration of Chinese Lakes and rivers ecosystem.

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A principle pyramid water molecule with 4 equilateral triangle planes and 6 equi-edges of 0.48017 nm had been developed, which can be used for improving water quality as a basic theory. The landscapes developed during long history with clean water and abound macrophyte and biodiversity may assume as the healthy aqua-ecosystems, possessing thresholds as the targets for restoration engineering. The basic principles are to transform the pollutants in water into usable resources and take off from the water, improving the purifying capacity in water mainly by the solar energy. The technology of immobilized nitrogen cycling bacteria should be used for more efficiently decompose the pollution organics in water. The subsystems of floating eco-islands are essential to be constructed on which can culture various plants and mollusks during different seasons with mosaic technology. Controlling of mass exchange rate for a healthy ecosystem with surroundings is essential for keeping their thresholds, using the enclosures with certain filtration rate made from polyester or plastic fiber with sufficient width to adapt the water level variation and maximum wave height is of great importance. The soft enclosures can be used to limit the spread of the pollutants in the limited areas as the “trash cans” for protecting the broad regions of healthy aqua-ecosystems. In the heavy polluted areas, where even the bacteria are difficult to live, may use the electric pulse technique, photosensitization technology, etc. Special techniques for suppressing the release of hydrogen sulfide were developed. The strategy of constructing tunnel-net-reservoir under farmland to store the rainfall for decreasing the probabilities of drought and flood disasters was proposed. The main theory and practice experiences of physic-ecological engineering (PEEN) for controlling eutrophication, improving water quality and restoration to meet the healthy drinking source water of Chinese lakes and rivers ecosystem were summarized in

this article.

S9-O Mixing Dynamics in Lakes from the Tropics to the Poles. *Sally MacIntyre*

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Charles Goldman has led limnological studies in lakes worldwide, some small, as Castle Lake, California, some large to exceptionally large, as Lakes Tahoe and Baikal, and some with unusual thermal regimes, such as lakes in the Antarctic. Here I contrast key factors determining the extent of mixing of the African Great Lakes and how mixing dynamics of small lakes vary by latitude. Mixing caused by heat loss induces deeper mixing in tropical than temperate or arctic lakes, and internal wave induced mixing is critical in lakes at all latitudes. Horizontal convection is a key determinant of flow under the ice in Antarctic lakes as in Arctic lakes. Using classification schemes developed to characterize internal waves and convection, I illustrate key controls on fluxes of nutrients and dissolved gases as they affect ecosystem productivity and greenhouse gas emissions.

S9-O How does terrestrial subsidy sustain secondary production in lakes?: roles of the grazing- and detritus-food chains. *Fumiya Hirano[1], Jotaro Urabe[1], Takehiro Kazama[1], Takumi Noguchi[1], Tekehito Yoshida[2], Masato Yamamichi[2], Izumi Katano[3], Hideyuki Doi[4], Tyler Tappenbeck[5], Jim Elser[5]*

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Most lakes are net heterotrophic ecosystems in which communities are sustained not only by organic matter produced within the lake (autochthonous production) but also by organic matter produced in the watershed and discharged into them (allochthonous production). Quantitatively, one of crucial sources of allochthonous production to lakes are fallen leaves of trees in the surrounding watershed. However, it is not necessarily clear how these terrestrial subsidies sustain lake communities. It is likely that the fallen leaves stimulate detritus-food chains by supplying energy or C sources for bacteria that in turn are grazed directly by metazoan zooplankton or indirectly via grazing on protozoans. Alternatively, since fallen leaves contain nutrients such as N and P, these may stimulate grazing-food chains by supplying nutrients to algae, a major food source for zooplankton. To examine which of these pathways (grazing- or detritus-food chains) are more stimulated by inputs of fallen leaves, we performed an enclosure experiment in a small lake of Montana. In the experiment, we manipulated light supply (to manipulate autochthonous production) and inputs of crushed fallen leaves of deciduous and conifer tree species (to manipulate allochthonous input) in replicate mesocosms and monitored responses of zooplankton to these manipulations for two months in summer. In this talk, we present results of the experiments and discuss potential shifts in the relative importance of grazing- and detritus-food chains in response to terrestrial subsidies lakes from the view point of ecological stoichiometry.

S9-O Boreal lakes in the global carbon cycle - not just a drop in the pond.

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During the past decade it has been realized that lakes are important components of the global carbon cycle. In particular, research has focused on the lakes of the circumpolar boreal zone. They comprise a large share of all global lakes and lake area, and they have been found to be intense sites of transformation of organic matter imported from the terrestrial surroundings, carbon burial, and emissions of methane and carbon dioxide. This presentation will discuss some of the achievements that have been made in the study of carbon cycling in boreal lakes. It will include how watershed characteristics and water retention time affect in-lake metabolism, the content and composition of organic matter, and how various factors (e.g., microbial and photochemical mineralization) affect the role of lake as sinks and sources of atmospheric carbon dioxide. Anthropogenic pressures affect the lakes and their role in carbon cycling. Such pressures include changes in the watershed by forestry or other land use change, and erosion and subsequent transport of inorganic particulate matter. Additionally, in large areas of the boreal and temperate zones, lakes have been found to get browner due to increasing content of dissolved organic matter. Several (not mutually exclusive) reasons for browning include recovery form acidification, climate change, and land use change; consequences include not only changing ecosystem structure, but in some areas also a challenge to the drinking water industry. Similarities and differences between boreal lakes and global lakes will be discussed.

S9-O Resistance and Resilience of Large Lakes to Disturbance: A View from Lake Baikal.

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The pelagic and coastal zones of large, deep lakes may differ in resistance and resilience to disturbance. For example, at L. Baikal, pelagic chlorophyll concentrations have changed little over the last 30-60 years suggesting that the pelagic zone is relatively resistant to eutrophication, as expected for a lake of immense volume and no internal loading of phosphorus. In contrast, the nearshore zone appears remarkably sensitive to nutrient pollution. Beginning in ca. 2011, localized coastal areas began experiencing severe benthic eutrophication with large wash-ups of benthic algae accumulating onshore. Nutrient inputs are high where coastal wash-ups occur due to sewage discharge, but even low concentrations of nutrients from contaminated groundwater can fuel excess growth of benthic algae. Resilience, the rate at which an ecosystem returns to its equilibrium state after a disturbance, may also differ between the pelagic and nearshore zones of this lake. A recent historical study of heavy metal concentrations in the Baikal seal (Pusa sibirica), the top predator of the lake's pelagic food web, suggests that resilience may be surprisingly high in the pelagic zone. Concentrations of Hg and Cd in archival seal teeth peaked in the 1960's – 1980's, but returned to levels recorded in the 1930's by 2013. In contrast, resilience of the coastal zone to eutrophication and contaminants is unknown. It may be considerably less than that of the pelagic zone where nutrients and contaminants emerge slowly from the catchment groundwater

into nearshore areas. In addition, slow growing organisms vulnerable to pollution in the coastal zone (e.g., sponges) will necessarily recover slowly. Thus, the coastal zone community of L. Baikal may be both less resistant and resilient than the pelagic community. Such contrasting features of the coastal and pelagic zones of large lakes have important implications for both research and management.

S9-O Highly intermittent phytoplankton dynamics: meter scale to millimeter scale.

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Phytoplankton requires both light and nutrient, thus requires staying in the upper ocean where turbulence stirs water column. Turbulence mixes oceanic properties, such as salinity and temperature. How does it mix phytoplankton? How do they distribute in space. Traditionally, biologists use Niskin Bottle (~1 m) to sample water in order to identify phytoplankton cells and measure the average concentration of chlorophyll. Therefore, no information is available how phytoplankton distributes below one-meter scale. A conventional CTD mounted cage may caries a Seapoint chlorophyll fluorometer that allows a fine scale observation of fluorescence. But the configuration of the probe prevents without disturbing the phytoplankton natural distribution. We introduce how to measure phytoplankton at a micro scale without agitating the natural field. We have developed two types of fluorescence probe, LED (~2 cm resolution) and laser (~2 mm resolution) and mounted these probes on a free-fall microstructure profiler (TurboMAP-L). Both probes measure phytoplankton distribution without agitating the field. We have found the LED data are significantly different from the laser data that exhibit highly intermittent features. The variability may be quantified by the coefficient of variation (CV=standard deviation/mean). The millimeter scale fluorescence field exhibits considerably high intermittency attaining that the CV exceeding 1. The local signals are considerably stronger than the spatially average signal. We also mounted a mini-camera system on the microstructure profiler TurboMAP-L to identify the source of intermittent fluorescence signals and found the strong signals came from marine aggregates. From ten different field campaigns we compiled the average size of aggregate and the average rate of kinetic energy dissipation rate and found they are positively correlated. The implications of the field data will be presented in this talk.

S9-O When do Cyanobacteria and Ceratium respectively dominate summer phytoplankton in stratified Danish lakes?

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Since domestic wastewater purification was implemented in Denmark in the early 1990s, Ceratium furcoides has gradually replaced Cyanobacteria during the climax summer succession in many stratified Danish lakes (19-22 ºC). Common for the lakes are increasing summer depletion of Ninorg, P Inorg., and Si in the epilimnia, increasing anoxia in the hypolimnia, with concomitant release of historical anthropogene P from the sediment. The released P is captured in the hypolimnion until autumn circulation sets in. During summer, the thermocline gradually deepens, and the oxicline gradually rises through the water column. In some of the lakes, C. furcoides dominates in some years, and Cyanobacteria in other years. Examples are given from 6 seasonally stratifying Danish lakes. By comparing various competition strategies of large dinoflagellates and

Cyanobacteria from the literature, this paper attempts to elucidate when and why the shifts between these two climax strategists take place in Danish lakes.

S9-O Long-term Changes in Cyanobacteral Populations and Eco-physiological Outlook in Lake Kinneret, Israel.

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Israel Oceanographic and Limnological Research, The Kinneret Limnological Laboratory, Israel

The abundance and composition of cyanobacteria in Lake Kinneret, Israel, have changed during the last five decades. New invasive species of the order Nostocales (Aphanizomenon ovalisporum and Cylindrospermopsis raciborskii) became part of the annual phytoplankton assemblage during summer-autumn. Concomitantly, bloom events of *Microcystis* sp. (Chroococcales) during winter-spring intensified. These changes in cyanobacteria pattern may be partly attributed to the management policy in Lake Kinneret's vicinity and watershed, and partly to climate changes in the region; i.e., increased water column temperature, less wind and reduced precipitation. From a perspective of almost five decades, it is evident that Lake Kinneret is experiencing a gradual decrease in the concentration of total and dissolved phosphorus, total, dissolved nitrogen and an increase in alkalinity, pH and salinity, and combined with the physiological features of cyanobacteria probably contributed to their success in the lake. The increase in the abundance and diversity of cyanobacteria in Lake Kinneret and the establishment and persistence of Nostocales in the lake may provide an example of the expansion of Nostocales worldwide.

S9-O Monsoon-based variations in the vertical profile of selected limnological parameters in the Seven Maar Lakes (SML's) of Laguna (Luzon Is., Philippines): A unique insight into the limnology of tropical maar lakes.

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The Seven Maar Lakes (SML's) are a cluster of small lakes of volcanic origin all located within a single town (San Pablo) in the province of Laguna in Luzon Is. These lakes serve the local communities through their multiple resource use, particularly through aquaculture, open water fisheries and ecotourism. Unfortunately, very few information on many aspects of the ecology of these lakes are available to the larger scientific community. Furthermore, an in-depth analysis of the impacts of monsoon-driven changes on its limnology have not yet been conducted, despite its role in the limnological dynamics of tropical lake ecosystems. This study analyzed the spatio-temporal trends of limnological characteristics and their relationship with the prevailing monsoons in the SML's. Meteorological data (air temperature, total rainfall, and wind speed) were gathered from the local weather station while limnological parameters were collected using a CTD profiler monthly from October 2016 up to December 2017. Results showed that variable thermocline depths were found across all lakes depending on depth while partial mixing was observed during the northeast monsoon. Variations in the vertical profile of dissolved oxygen levels were related with the amount of rainfall and thermocline depth. Air temperature had a very strong positive correlation (r=0.9655, p value=0.001) to thermocline thickness, while total rainfall showed a modest negative correlation (r=-0.4640, p value=0.294), while wind speed had a strong negative correlation (r=-0.8356, p value=0.019). Our results show that prevailing meteorological

conditions influence lake dynamics of all the SML's at varying intensities, which may then be related to the topography of the surrounding watershed. These novel information on the limnology of the SML's of San Pablo are important factors to consider in future lake management and rehabilitation efforts. This is the first time that routine monthly observations of basic limnological features of all the SML's had been carried out.

S9-O Advanced ICT for monitoring freshwater ecosystem resilience.

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This project will establish an advanced Information and Communication Technology (ICT) for monitoring large lakes, interpreting their current condition and predicting variations as an essential tool for management. Project aims are: (1) early detection and location of toxic cyanobacterial blooms, a worldwide concern for drinking water safety in lakes or reservoirs, with ASV routine monitoring; (2) prediction of their expansion using now-casting of aquatic ecosystems; (3) evaluation of risks to ecological resilience by means of non-linear causality analysis; and (4) show how we can inform people of rising risks using a Social Network System. We have successfully developed some aspects of these technologies over the last two decades and will now advance and incorporate them into a compact unified system. The proposed work will provide a system for Lake Biwa (Japan) and Lake Kinneret (Israel) that will be open to the public and other interested stakeholders. More generally, the ICT tools to be refined and integrated will help to solve difficult worldwide problems that will intensify with climate change, potentially abruptly, in the near future.

S9-O Spatiotemporal organization of the bloom-forming cyanobacteria *Microcystis* sp. in a deep lake: new methodology and insights.

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Blooms of toxic cyanobacterium *Microcystis* sp. become of common occurrence in many water bodies all around the world. The cyanobacteria affect functioning of aquatic ecosystems and deteriorate water quality. Much effort has been devoted to detect early stages of *Microcystis* blooms. The main difficulty in reliable monitoring stems from the heterogenic spatial distribution of the cyanobacterium. We developed a novel hydroacoustic approach to monitor and study the spatiotemporal organization of gas-containing *Microcystis* populations. We used the EY60 Simrad echosounder and Teledyne Sentinel ADCPs in combination with LISST-100x and Flouroprob water column profilers to study the vertical distribution of *Microcystis* sp. in Lake Kinneret (Israel). These results were verified versus the FowCam and microscopic observations. The backscattering signal obtained with EY60 was calibrated versus chlorophyll a concentration (a proxy of *Microcystis* biomass during its bloom). To investigate the impact of meteorological forcing and change in physical structure of the water column on *Microcystis* distribution, the meteorological and thermistor chain data were studied. We revealed the distinct near-diurnal patterns of *Microcystis* vertical distribution in late winter and early spring. The observed variations in vertical distribution of *Microcystis* were associated with diurnal thermocline development and turbulent regime in the upper part of the water column. Formation of *Microcystis* surface scum dependents on turbulent motions in the upper part of the water column and water surface temperature regime. The role of *Microcystis* surface scum in bloom formation is discussed. The

results obtained during this study increase our ability to develop more accurate models to forecast *Microcystis* blooms and better evaluate the role of climate change on proliferation and blooming of this harmful cyanobacterium.

S9-O Data Assimilation: from weather prediction to Lake Biwa nowcasting.

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Data assimilation plays a key role in numerical weather prediction, combining computer models with real-world data through dynamical systems theory and statistical mathematics. Computing, sensing, and information/communication technologies are advancing rapidly, and data assimilation is becoming more popular as a means of cyber-physical fusion in broader science and technology fields. At RIKEN, the Japan's flagship research institute for all sciences, we have been pioneering the future possibilities of numerical weather prediction by taking advantage of the powerful K supercomputer and Big Data from advanced sensing technologies such as the phased array weather radar and Himawari-8 geostationary satellite, at the scales ranging from global to convective at the resolution as high as 100 m. We have been further exploring new applications of data assimilation to brain, medical, biological, and ecological sciences as well as engineering applications, and identified common denominators. Here, we will present some excitement of RIKEN's activities on data assimilation for severe weather forecasting, followed by a perspective toward Lake Biwa nowcasting.

S9-O Acoustic Tomography in the North Basin of Lake Biwa, Japan.

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We will present results from Coastal Acoustic Tomography (CAT) at horizontal ranges up to 14 km under stratified conditions, believed to be the first field demonstration of CAT in a lake under stratified conditions. Our long-term purpose is to track currents and other physical fields by assimilating the CAT data, and other available data, into an operational forecast system. Fluctuations in acoustic arrival times reflect changes in temperature, but our priority is to infer path-averaged currents from Differential Travel Times (DTT) during reciprocal transmission.

The tests were performed in Nov 13-18, 2016 and Nov. 10-28, 2017 in the North Basin of Lake Biwa, with average (maximal) depth of 41 (104) m. Even at the end of the 2017 deployment, epilimnion temperatures were about 13ºC, versus 8ºC in deep water. Acoustic ray-tracing simulations predict that sound is strongly refracted at the thermocline. Accordingly, the thermocline acts as a mirror, and sound mostly passes through the hypolimnion. The western station for both tests was a water intake with a bottom depth of 9 m, while the easternmost station was changed between 2016 (Bottom Depth 35 m) and 2017 (BD 49 m). In Nov. 2017, at a range of 10.2 km, two-way or "reciprocal" transmission was achieved most of the time, with small but significant differences in eastward versus westward travel times. Under the assumption that path length in the two directions was equal, one computes path-averaged currents around 5 cm per second, which agrees with the magnitude of currents to be expected in the deep water. Large fluctuations in signal level were observed, which might be due to internal waves modulating the sound channel. We will refer to data from 3D hydrodynamic simulations, and from thermistor chain records, to interpret these and other characteristics of the CAT data.

S9-O Horizontal transportation of nutrients from littoral slope and enhancement of phytoplankton growth in north basin of Lake Biwa.

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Nutrient loading from non-point source in a lake ecosystem has not been well recognized yet. In Lake Biwa, TP does not decline to the level before eutrophication period despite of decreasing the loading from point sources surrounding the lake. We have gotten some evidences for transportation of nutrients from the sediment of littoral slope in north basin of Lake Biwa through several transect surveys. Although soluble reactive phosphorus (SRP) in a mixing layer was always below the detection limit, sub-surface ammonium maximum layer along from littoral to offshore could be detected after discharge of waste water from rice paddy, when the rice planting had just done. Through our 6 times transect surveys for determining vertical profiles of nutrients, methane and herbicides, we detected sub-surface maximums layer of ammonium and methane as a proxy of materials transported from interstitial water in the sediment of littoral slope. Herbicides, which were used in rice paddy during the rice planting and a proxy of materials transported from terrestrial environments surrounding the lake, were also detected in sub-surface of the offshore lake water. These results suggested that nutrients for enhancing algal growth might be horizontally transported from sediment in the littoral slope, and that the source of the nutrients might be provided from the waste water of rice paddy. The mechanism for transporting the nutrients from the rice paddy to pelagic area was still unknown, because of no information on in situ spatial distribution of phosphate due to the detection limit of SRP in the lake water until recently. Now, we developed new technique for determining orthophosphate from the lake water in nano-mole level, and planned to obtain the spatial distribution of orthophosphate through a transect survey. The results will be also provided in our presentation at the conference.

S9-O Gyres and their biogeochemical consequences for lake ecosystems.

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Wind stresses on a lake's surface are the primary forces generating motions in lakes. These excite primary water motions such as seiches, basin-scale internal waves and gyres. They then generate secondary motions, such as high-frequency internal waves and residual circulation. Not surprisingly, the amplitude and spatial structure of these motions have significant implications for chemical and biological processes in lakes since they regulate biogeochemical flux paths. Considerable research has been undertaken in lakes around the world to understand the spatial structure and excitation of primary motions in lakes. In Lake Biwa, the largest lake in Japan, we deployed an ADCP (Acoustic Doppler Current Profiler) 2 km off the east shore and measured water currents 2003. We concurrently measured the distribution of zooplankton and chlorophyll. Zooplankton distribution was strongly affected by the structure of the gyre with *Daphnia galeata* and Bosmina longirostris being greatest near the gyre centre – areas where upwelling occurred. Phytoplankton might also have been transported upward but this was not clear from our data. Few studies have looked at the physical structure and distribution of plankton, probably due to the difficulty in measuring biological dynamic responses while concomitantly getting measures of spatially large coverage of hydrodynamic processes. Too seldom are modern measures of, and analyzes of, hydrodynamical processes incorporated into research in aquatic ecology and vice versa.

S9-P Seasonal change of photosynthesis of phytobenthic communities in Antarctic lakes.

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The most luxuriant vegetation is found in freshwater lakebeds as thick phytobenthic mats in East Antarctica. Photosynthetic activities of phytobenthic mats are measured well in many lakes on Antarctica during summer, whereas little is known about it for a period from autumn to spring. We collected phytobenthic mat samples from Lake West Ongul (69° 01′ S, 39° 33′ E) in Sôya Coast, East Antactica once or twice per month throughout the year except June, and from nine freshwater lakes (69° 14′ S-69° 30′ S, 39° 33′ E-39° 47′ E) in Sôya Coast, East Antactica in both summer and early-spring during 2017-2018, of which two lakes were a target of continuous monitoring of PAR (photosynthetically active radiation) and temperatures underwater by installing mooring systems. Then, we measured photosynthetic characteristics using a chlorophyll fluorescence instrument (Phyto-PAM, Walz) as soon as possible after arrival in the base, and rest of the samples were frozen in the dark at -20°C for analyzing the pigments composition as an index of light-utilization and photo-community composition. The photosynthetic activities peaked in early spring, then decreased toward summer although phototrophs can most get light energy in a year.

S11. Lake restoration: mitigating eutrophication and controlling harmful cyanobacterial blooms or nuisance weeds

S11-O The importance of in-lake actions in mitigating eutrophication nuisance.

Miquel Lürling[1], Maíra Mucci[1], Frank van Oosterhout[1], Guido Waajen[2]

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More than 99% of the stagnant surface waters on the planet are smaller than 100 hectares. These relatively small lakes, reservoirs and ponds are often close to urban settlements where they deliver important services to people. However, many also suffer from anthropogenic pressures including eutrophication. In The Netherlands, eutrophication is the main reason for not meeting the E.U. Water Framework Directive targets, despite The Netherlands has among the best wastewater treatment works on the globe and has tackled point source nutrient pollution efficiently. Diffuse nutrient pollution and legacies from the past keep on fueling cyanobacterial blooms that make in-lake interventions an absolute necessity to mitigate nuisance. To this end, a proper diagnosis – a system analysis – sheds light on what interventions might be most successful. As an example, the results of two geo-engineering in-lake interventions of combined coagulant and phosphate fixation to clear the water column and block release of phosphorus from sediments will be presented. The system analysis had revealed internal loading in these lakes as the main driver of cyanobacterial blooms hampering recreation, where the internal load was a result of years of diffuse nutrient inputs. The in-lake “shock-therapy” moved both lakes to a far better water quality for about seven and ten years with costs of €3000, and €1900,- per hectare per year, respectively. The relatively small size of the lakes (2.6 and 6.7 ha) implies costs are less than the annual costs for maintenance of the beaches and lawns. However, in ensuring water quality suited for recreational activities repeated in-lake actions will be needed due to ongoing nonpoint nutrient loading. Given the worldwide increase in eutrophication nuisance those techniques that repeatedly remove cyanobacteria out of the water column could be considered to bring real-time relief until

catchment measures, point- and nonpoint source control have become effective.

S11-O Lakeside wetland as a trap in cyanobacteria and nutrient removal and capture ability in Lake Chaohu.

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Lake Chaohu is the fifth large freshwater lake and is located in Anhui province, China. Eutrophication has been very serious since 1970s. The water body often breaks out cyanobacteria blooms because of higher nutrients and lakeside wetland loss. Recently, a large amount of lakeside wetland were rehabilitated in this lake for water quality improvement and ecological restoration. The results of field investigation showed that lakeside wetland as a trap had positively significant effect on removal and capture of cyanobacteria and nutrient. Comparison between the littoral zone with and without wetland, algal biomass captured by lakeside wetland was up to 360 g/m^2.d. The nitrogen of 28.6% and the phosphorus of 32.8% come from cyanobacteria entered sediment for growth of phragmites communis. Therefore, Lakeside wetland as a trap has a great contribution to reduce cyanobacteria and nutrient of open area in Lake Chaohu.

S11-O Use of nature-based solutions for the management of eutrophic lakes: the case of Lake Pusiano (North Italy).

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The abatement of the external nutrient loads is the principal lake restoration strategy indicated by the most advanced laws for water protection (e.g. the European WFD). In Italy the main management actions to reduce external nutrients loads have been carried out between the 1980s and the 1990s when the phosphorus content in detergents was reduced, most of the sewer systems completed and the waste water treatment plants developed. Such an enormous effort however presents one main limitation consisting in the lack of separation between urban runoff waters and domestic effluents, both collected in combined sewer systems. Through the presence of sewer overflows, during high precipitation events these systems discharge their effluents directly into surface waters. The infrastructural solution of this problem involves the rebuilding of the sewer system and presents very high costs. A substantial mitigation of the problem, however, can be obtained through the development of nature-based solutions (e.g. the 2018 UN World Water Development Report). The increase of permeable areas may reduce the inflow of urban runoff waters in sewer systems and thus the discharge of sewage in surface waters. This can be obtained for example increasing the extension of the vegetated areas and/or promoting the development of green roofs in the lake basins. The applicability of these methodologies in the real case study of Lake Pusiano and the preliminary results of an experimental field set up near Milan to evaluate the capacity of green roofs in reducing the nutrient loads, will be discussed in this contribution.

S11-O Whole lake combined PAC-Phoslock® treatment to manage eutrophication and cyanobacteria.

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Lake de Kuil (The Netherlands, 6.7 ha, maximum depth 9 m) suffered from cyanobacterial blooms since the early 1990-ies as a consequence of eutrophication. Point source reduction did not yield improved water quality due to high internal loading. To control internal loading and cyanobacteria the lake was treated with a low dose of flocculent (4 tons of iron chloride) and a solid phase phosphate sorbent (42 tons of Phoslock®) in May 2009. The treatment aimed to target both dissolved and particulate phosphate, and to block P-release from the sediment. The treatment was successful reducing total phosphate, chlorophyll-a and increasing water quality. Ongoing diffuse P-inputs, however, have gradually moved the lake back towards a eutrophic state. Thus, a re-application of flocculent and Phoslock® was done in May 2017. We have been monitoring the lake before, during, and after the application. Water samples over depth were taken to analyse nutrients, chlorophyll-a, turbidity, cyanotoxins and pH. In situ, Secchi depth, oxygen and light profiles were made. On May 8th, 8 tons of Phoslock® were applied to the lake (30 mg L^{-1}) as ballast to sink the algae. The day after six tons of Polyaluminium chloride was applied (2.1 mg Al L^{-1}) to flocculate the cells, while on May 10th 23 tons of Phoslock® was injected in the hypolimnion layer (4-5 meters) only in the deeper part of the lake to target the internal loading. The results of the monitoring will be presented shedding light on the efficacy of the treatment.

S11-O Nutrient Control in Water Bodies the Biocleaner Way. *Dennis Tee*

Biocleaner Inc., United States

For many years, nutrients such as Nitrogen and Phosphorus have been contaminated lakes and rivers around the globe and is now considered one of the most widespread and costly environmental problems to this day.

The major characteristics that differentiates our bioreactors from other treatment systems is the use facultative and saprobic geobacters. This means our microbes are able to live in environments even if there is no oxygen available and that they will digest any dead or decaying organic matter. Our all natural and non-GMO microbes produced by our bioreactors are able to control Phosphorus and Nitrogen levels in the water. Other contaminants present in the lake such as Ammonia, is broken down into Nitrites by our nitrifying microbes and further broken down into Nitrates and finally into Nitrogen by our denitrifying microbes. Nitrogen is then released to the atmosphere. We also use the ecosystem to remove Phosphorus from the lake. Phosphorus is taken up by our microbes, these microbes are then absorbed by chlorella which in turn is eaten by small fish. These small fish are eaten by bigger fish and eventually end up caught by men.
Our technology is designed to remove Cyanobacteria and its toxins by outcompeting the algal bloom of its resources. It will create an environment where Cyanobacteria will no longer proliferate and with time it will eventually all die off. This new environment will encourage chlorella growth.

Sludge at the bed of the lake will also be digested by our saprobic microbes since sludge is mostly composed of dead bacteria shells.

The combination of treating nutrients, outcompeting cyanobacteria, introducing fish and the chlorella will result in the full rejuvenation of the lake. At which point will be no more need of geoengineering in the form of chemical coagulants.

S11-O Adaptation of bloom-forming Planktothrix agardhii to nitrogen depletion. *George S. Bullerjahn[1], Michelle Neudeck[1], Katelyn McKindles[1], Robert M. McKay[1], Justin Chaffin[2], Kateri R. Salk[3], Nathaniel E. Ostrom[3]*

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Whereas much attention has been devoted to studying the *Microcystis* harmful algal bloom (HAB) events in the Laurentian Great Lakes, tributary sites are often affected by persistent blooms of Planktothrix, a filamentous microcystin-producing cyanobacterium. Our labs are examining the factors that allow these organisms to occupy different ecological niches. Regarding Planktothrix, HABs are typically of longer duration (May-October), routinely yielding microcystin levels in excess of 20 ppb. In agreement with prior studies on Planktothrix blooms in Ohio (USA) reservoirs, Sandusky Bay midsummer dissolved inorganic N concentrations often fall below detection, and bottle assays indicate that enhancement of summertime bloom conditions is often dependent on N additions, rather than P. Losses of N in Sandusky Bay are attributed in part to high rates of denitrification in the sediments. We hypothesize that N availability is a major driver of Planktothrix dominance, distinct from open water *Microcystis* HABs in which P is traditionally viewed as the key factor for biomass production. The success of Planktothrix in an N-limited system is notable given that this genus is not an N fixer, but metatranscriptomic analyses reveal a minor cyanobacterial community of N fixers contributing new N into the system. Gene expression related to ammonium uptake (glnA, amt) and cyanophycin metabolism (cphA, cphB) point to luxury uptake and N storage during periods of N abundance. Analysis of Sandusky Bay blooms by qPCR and 16S iTags also reveals that Planktothrix presence and abundance is correlated with N speciation. We propose that in general, Planktothrix agardhii is well adapted to environments prone to rapid shifts in N availability, and that management of N will be warranted to mitigate bloom events.

S11-O Static layer: A key to phosphorus immobilization in sediments amended with aluminum sulfate and lanthanum modified bentonite.

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There is a great heterogeneity in the distribution of mobile phosphorus (P) in natural sediments, while the assessment of P immobilization by amendment agents has mostly neglected this feature. In this study, the effects of aluminum sulfate (ALS) and lanthanum modified bentonite (LMB, Phoslock®), on P immobilization were investigated via a 60-day dose-experiment treated with different doses and a 110-day time-experiment sampled on different times with a fixed dose. The high-resolution dialysis (HR-Peeper) and diffusive gradients in thin films (DGT) techniques were employed to establish the profiles of soluble reactive P (SRP) and DGT-labile P in ALS-amended and LMB-amended sediments at mm resolutions. In the dose-experiment, the removal rates of SRP in the overlying water were higher than 78% in 6-15 ALS/Pmobile and 60-200 LMB/Pmobile treatments. Both concentrations of the two mobile P forms decreased with increasing ALS and LMB dosages in the sediment profiles. Stratification was observed in higher dose treatments (6-15 ALS/Pmobile and 60-200 LMB/Pmobile) in dose-experiment and between 45-110 days in time-experiment, with a static layer (with extremely low mobile P concentrations) in the top 20 mm of sediment being followed by active layers (with relaxed upward diffusion gradients apparent). This was caused by the increased difficulty of P release from labile solid P pool after capping, which was reflected by the increases in distribution coefficient of P between the solid pool and pore water (Kd) and the adsorption rate constant (k1). It is suggested that the formation of the static layer is the key to efficiently retain the capping effect.

S11-O Comparison of biomass removal and hydrogen peroxide treatment in mitigating bloom-forming cyanobacteria.

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One of the most common features of eutrophication is recurrent blooms of cyanobacteria, which posed serious threats to water resources. Controlling bloom-forming cyanobacteria (BFC) is a high priority for environmental regulatory agencies, especially when the nuisance dense scums are forming and affecting the household water supply. Biomass removal and hydrogen peroxide treatment are regarded as the efficient end-of-pipe measures to mitigate BFC. To evaluate the control effectiveness of filtration method (algal removal by filtration with 30-μm-mesh nets) and hydrogen peroxide (H_2O_2) treatment on BFC, a 15-day mesocosm experiment was conduct at the shore of Lake Taihu. The biomass of BFC under three removal intensities (30%, 50%, 70% biomass reduction in PC) increased rapidly from the very beginning, and reached the maximum on day 9, with the average BFC growth rates being around 0.20 day^{-1} and 0.11 day^{-1} for the biomass removal treatments and for the control, respectively. Meanwhile an interspecific shift from *Microcystis* sp. to *Anabaena* sp. was observed after reducing BFC biomass through filtration. In contrast, 10.0 mg/L H_2O_2 treatment selectively suppressed BFC throughout the experimental period with relatively weak impacts on eukaryotic phytoplankton, leading to a population succession after day 6. The impacts of BFC mitigation methods on the concentration of microcystins were related with the loss of cell integrity and interspecific succession.

S11-O Temperature-dependent lag effect of chlorophytes on mixotrophic *Ochromonas* eliminating toxin-producing *Microcystis*.

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Cyanobacterial blooms, caused by eutrophication and climate warming, exert severely negative effects on aquatic ecosystem. Some species of protozoans can graze on toxic cyanobacteria and degrade microcystins highly efficiently, which shows a promising way to control the harmful algae. However, in the field, many different species of algae coexist with *Microcystis* and may affect protozoans eliminating *Microcystis*. Therefore, in this study, we assessed the impacts of chlorophytes, a type of beneficial algae for zooplankton and common competitors of cyanobacteria, on flagellate *Ochromonas* eliminating toxin-producing *Microcystis* at different temperatures. Our results showed that *Ochromonas* still eliminated *Microcystis* population and degraded the total microcystins with the addition of chlorophytes, although the time of eliminating *Microcystis* was prolonged and temperature-dependent. Additionally, in the grazing treatments, chlorophytes populations gradually increased with the depletion of *Microcystis*, whereas *Microcystis* dominated in the mixed algal cultures without *Ochromonas*. The findings indicated that although chlorophytes prolong mixotrophic *Ochromonas* eliminating *Microcystis*, the flagellate grazing *Microcystis* helps chlorophytes dominating in the primary producers, which is significant in improving water quality and reducing aquatic ecosystem risks.

S11-O The existence of cyanobactericidal and growth-inhibiting bacteria on the water plant *Trapa jeholensis* and an evidence of quorum sensing involving the kill of *Microcystis Aeruginosa*.

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One promising tool for preventing occurrences of toxic blooms of the cyanobacterium *Microcystis aeruginosa* is the use of cyanobactericidal bacteria (CB) and growth-inhibiting bacteria (GIB). The abundances of *M. aeruginosa* as well as CBs and GIBs against *M. aeruginosa* were investigated in the moat at Goryokaku Park, Hakodate, Japan, in 2015. Isolated bacterial colonies from water and the water plant *Trapa jeholensis* were co-cultured with an axenic *M. aeruginosa* strain (Ma17) to estimate CBs and GIBs. The abundance of *M. aeruginosa* in the water fluctuated between 3.6×10^2 and 8.4×10^3 cells mL^{-1} . Abundances of CBs and GIBs were 1.2×10^3 colony forming unit (CFU) mL^{-1} and 8.3×10^2 –1.3×10^4 CFU mL^{-1}, respectively, in the water, but much more abundant on *T. jeholensis* (6.2×10^5 CFU g^{-1} in June and 4.5×10^5 CFU g^{-1} in August for CBs, and 1.9×10^6 –2.7×10^7 CFU g^{-1} from June to September for GIBs). The results suggest that *T. jeholensis* is the source of CBs and GIBs to the surrounding water. Isolated CBs and GIBs (total 30 clones) were used to study on killing mechanisms against *M. aeruginosa* via quorum sensing mediated by acyl-homoserine lactone (Auto Inducer 1). The bacterial clone strain 30 showed the negative effects on growth inhibiting activity by the addition of β-cyclodextrin. Further experiments using α- and γ-dextrin revealed that the degree of inhibition of cyanobactericidal activity was in the order of α- < β- < γ-dextrin, corresponding to subsuming molecular size, suggesting relatively higher molecular weight of Auto Inducer I for the strain 30. The present study revealed the abundant existence of cyanobactericidal bacteria against *M. aeruginosa* on the surface of water plants and the mediation of quorum sensing as killing mechanism against *M. aeruginosa*.

S11-O Toxic *Microcystis* is more sensitive to allelopathic effect from juglone than the green algae Scenedesmus.

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The elimination of cyanobacteria blooms has become an urgent issue in aquatic environmental protection. Allelopathic control is considered as a potential approach for its exclusive and ecological safety properties. The present study evaluated the allelopathic effects of juglone, a derivative from the genus Juglans, on the toxic *Microcystis* aeruginosa. We firstly compared the growth inhibition of juglone on *M. aeruginosa* and the green algae *Scenedesmus obliquus*, which showed that 3.0-9.0 mg L^{-1} juglone depressed the population proliferation and photosynthetic performance of *M. aeruginosa* much severer than did on *S. obliquus*. The growth inhibition rate of *M. aeruginosa* treated by 9 mg L^{-1} juglone reached ~ 80% after 11-day exposure. The antioxidant enzyme activity (SOD and CAT) in juglone groups increased significantly, suggesting the juglone-induced oxidant stress in *M. aeruginosa* cells. In addition, juglone exposure enhanced the intracellular microcystins production per cell, but had no impact on the extracellular microcystins release. Combined with the decreased cell abundance, there was no increase in the total amount of microcystins in cyanobacterial culture medium. These results indicated the ecological safety of juglone and its potential application for *M. aeruginosa* extermination.

S11-O Restoration of a subtropical eutrophic lake in China: responses of nutrient levels and biological communities.

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While numerous reports exist on the results of lake restoration initiatives in temperate regions, only a few exist from subtropical lakes. We present results of the lake restoration of shallow, subtropical Lake Wuli, China, conducted between 1999 and 2015. After restoration, annual average concentrations of total nitrogen, total phosphorus (TP), and chlorophyll a and the chemical oxygen demand declined significantly, though summer TP remained high. Suspended solids decreased unsignificantly over the years. Transparency increased in winter, whereas decreased in summer and annually. The contribution of cryptophytes to total phytoplankton biomass decreased, while the proportion of cyanobacteria, especially potentially N_2-fixing species, increased. Rotifers were superseded by crustaceans as the dominant taxon of the zooplankton community. Enhanced abundance of *Daphnia* spp., appearance of *Leptodora kindti*, and increased biomass ratios of zooplankton to phytoplankton, calanoids to cyclopoids, and nauplii to copepods in the post-restoration period indicate reduced fish predation and stronger top-down control of phytoplankton. However, the high level of non-algal turbidity, probably caused by the higher biomass of benthivorous fish, apparently prevented the re-establishment of submerged macrophyte communities. We conclude that removal of fish, particularly benthivorous species, will further improve water quality in this and other subtropical shallow lakes.

S11-P The role of *Daphnia pulex* as a possible control of phytoplankton in three adjacent shallow lankes with different trophic state at Cantera Oriente, Mexico.

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Large zooplankton such as *Daphnia* play a fundamental role as consumers of phytoplankton. We experimentally analyzed the ability of *Daphnia pulex* to graze effectively on the phytoplankton community in three adjacent shallow lakes with different trophic states at Cantera Oriente (East Quarry)/México: North (mesotrophic), Central (eutrophic) and South (hypertrophic), with two outdoor mesocosm experiments per lake. Herbivorous d.*pulex* were cultivated under stable laboratory conditions and added only once in each mesocosm (80 ind L^{-1}). During cold-dry season of 2017, we collected phytoplankton & zooplankton samples, and measured selected physico-chemical variables *(chlorophyll a concentration (Chla), temperature, dissolved oxygen (DO), pH, conductivity, secchi disk transparency and nutrients)* once a week. The Chl*a* concentration reported a decreased from 66.09 to 5.80 µg L^{-1} for North, from 122.87 to 17.60 µg L^{-1} for Central and from 185.40 to 44.27 µg L^{-1} for South. Phytoplankton in North and Central lakes were dominated by the genus *Desmodemus* and *Cryptomonas*, and in South for *Microcystis*, *PseudAnabaena* and *Pseudopediastrum*. The Chl*a* concentration shows a general decrease on the fifth week, while d.*pulex* proliferated rapidly in mesocosms; the highest densities were reached: in

third week for the North with 83.87% algal removal efficiency (ARE, calculated using Chl*a* data), fourth week for the Central with 86,01% ARE and fifth week for the South with 76.22%, ARE. Although there is an evident negative relation between densities of phytoplankton and d.*pulex*, there weren´t a significant correlation between the values (Spearman's, p>0.05). These results suggest that, within the complex interactions brought about by trophic cascades, direct grazing by d.*pulex* is a strong driver regulating phytoplankton´s growth at any trophic state and at different phytoplankton composition; even though, *Daphnia* are scarce naturally in these lakes, their survivorship and growth inside mesocosm suggest an intense top-down control by the fishes.

S11-P Composition controls of dissolved organic matter interaction with La or Al: Implication into DOM potential influence on phosphorus immobilization.

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The application of aluminium (Al) salt or lanthanum (La) modified bentonite (LMB) has become a popular tool to immobilize phosphorus in eutrophic lakes. Humic substance had been reported to inhibit the immobilization of phosphate by LMB or Al treatment through reaction with metals (La, Al). Besides humic substance, the effect of other DOM, especially that from phytoplankton in eutrophic water needs more research. In this study, two types of DOM from diverse origins, i.e., Suwannee River Standard Humic Acid Standard II (SRHA) and algae-derived DOM (ADOM) were chosen as the target DOM. UV-Vis absorption spectra and excitation emission matrix fluorescence with parallel factor (EEM-PARAFAC) analysis showed the distinct difference in the optical signature between SRHA and ADOM. Three EEM-PARAFAC components, namely one polyphenol-like component (76.8%), one terrestrial humic-like components (14.5%) and one microbial humic-like component (6.7%) were identified in SRHA. While for ADOM, one humic-like component (37.1%), one tryptophan-like component (41.9%) and one tyrosine-like substance (21.0%) were found. There were two interaction processes between SRHA/ADOM with La/Al. One was the complexation at low metal inputs and the other was the coprecipitation at high metal inputs. Besides the polyphenol-like component, the terrestrial humic-like component in SRHA, the tryptophan-like component in ADOM had strong ability to complex with La. Also, the tryptophan-like component in ADOM could coprecipitate strongly with La and Al. Although the retard in P immobilization by ADOM was weaker than that by SRHA during La or Al treatment, the inhibitation of the tryptophan-like substance on the efficiency and longevity of LMB/Al treatment to immobilize P in eutrophic water should be paid attention to.

S11-P Effects of a lanthanum-modified bentonite and polyaluminium chloride on the sediment phosphorus forms in Lake Yanglan.

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Lanthanum (La) modified bentonite and polyaluminium chloride (PAC) can reduce sediment phosphorus (P) release and precipitate P from water column, and thus improve water quality. In this paper, we studied the effects of the application of lanthanum modified bentonite (Phoslock®) and PAC in Lake Yanglan (Hubei, China) on phosphorus forms of the sediment. The results showed that the content of La in the restoration area increased significantly in the top 8 cm of the sediment. The easily released NH4Cl-P, BD-P and Org-P contents in the sediments decreased and stable HCl-P and Ref-P contents increased, thus the phosphorus retention capacity of sediments

increased and the release risk of sediment phosphorus decreased.

S12. Lake Taihu in China: identifying consensus and future research priorities for one of the world's best studied polluted lakes

S12-O Geochemistry of Phosphorus and Heavy Metals between Sediments and Suspended Particles in Northern Lake Taihu, China.

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Lake Taihu, the third largest freshwater lake in China, is a very shallow, highly eutrophic, and polluted water body. Sediment resuspension events happen frequently at wind speeds above 4 m/s and are suspected to play a key role in nutrient and pollutant turn-over for the lake ecosystem. Therefore, it is necessary to understand underlying biogeochemical processes related to sediment resuspension events in order to develop effective mitigation measures for improved lake water quality and safe drinking water production in the future.
In this study, we investigated the distributions and binding forms of phosphorus and heavy metals in both sediment and suspended particulate matter (SPM) samples taken in northern Lake Taihu using an adapted BCR (Community Bureau of Reference) three-step sequential extraction procedure.

In general, we found a strong enrichment of phosphorus and heavy metals in SPM. However, the binding forms of these elements to particles were considerably different between surface sediments and SPM. Phosphorus and chromium in SPM were mainly bound to organic particles while copper, zinc, and cadmium were mainly bound to exchangeable sites and/or carbonates. In surface sediments, in contrast, phosphorus and heavy metals (except cadmium) were mainly bound to Fe-oxo-hydroxides. This means that there is a strong fractionation of elemental distributions and binding forms during the genesis of SPM related to biogeochemical processes. Either strong preferential resuspension of certain types of particles, or more likely in situ formation processes in the water column (like biomass buildup and $CaCO_3$ precipitation) are key drivers. Consequently, surface sediment composition cannot simply be transferred to SPM to describe its phosphorous and metal binding character. Thus, a more complex and process-based biogeochemical model would be necessary to predict the bioavailability and ecological effects of particle-borne phosphorus and heavy metals in Lake Taihu.

S12-O The influence of macrophytes on sediment resuspension and the effect of associated nutrients in a shallow and large lake (Lake Taihu, China).

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A yearlong campaign to examine sediment resuspension was conducted in large, shallow and eutrophic Lake Taihu, China, to investigate the influence of vegetation on sediment resuspension and its nutrient effects. The study was conducted at 6 sites located in both phytoplankton-dominated zone and macrophyte-dominated zone of the lake, lasting for a total of 13 months, with collections made at two-week intervals. Sediment resuspension in Taihu, with a two-week high average rate of 1771 g $\cdot m^{-2} \cdot d^{-1}$ and a yearly average rate of 377 g $\cdot m^{-2} \cdot d^{-1}$, is much stronger than in many other lakes worldwide, as Taihu is quite shallow and contains a long fetch. The occurrence of macrophytes, however, provided quite strong abatement of sediment resuspension, which may reduce the sediment resuspension rate up to 29-fold. The contribution of nitrogen and phosphorus to the water column from sediment resuspension was estimated as 0.34 mg $\cdot L^{-1}$ and 0.051 mg $\cdot L^{-1}$ in the phytoplankton-dominated zone. Sediment resuspension also largely reduced transparency and then stimulated phytoplankton growth. Therefore, sediment resuspension may be one of the most important factors delaying the recovery of eutrophic Lake Taihu, and the influence of sediment resuspension on water quality must also be taken into account by the lake managers when they determine the restoration target.

S12-O Development, Deployment and Added Value of a Profiling Buoy System for Water Quality Monitoring in Lake Taihu, China.

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Since a massive cyanobacteria dominated algal bloom in early June 2007 caused a shut-down of drinking water production for 4.43 millions of people in Wuxi, the water quality of Lake Taihu has aroused extraordinary concerns from all stakeholders. For local authorities to respond quickly and probably even prevent algal blooms beforehand, it is crucial to better understand the dynamically interacting processes in Lake Taihu, which lead to such serious algal bloom events in this shallow and highly eutrophic lake. Remote sensing applications by using multi-spectral satellite imagery can be used to estimate accumulation of phytoplankton at the water surface for a whole water body, but serious amounts of algae can also be present in the deeper water layers without being visible at the surface.

Our study aims at developing the new in situ and on-line monitoring platform ‘BIOLIFT’ (integrate nine physico-chemical parameters) to record depth- and time-resolved water quality profiles directly combined with meteorological data and corresponding frequent water samples. The multi-sensor system, weather transmitter, winch, control module and power supply are installed on a freely floating platform, which is built from pontoon elements.

There are now four well-evaluable time series of depth profiles of water quality by BIOLIFT at Lake Taihu in June/July 2016, February/March 2017, September 2017 and March/April 2018. This dataset provides high time-resolved insights into lake processes that are related to dynamic conditions in the vertical structure of the water column of Lake Taihu. These serve to describe and evaluate the different seasonal conditions and processes in the water column that can lead to quick formations of algal blooms. These results will contribute to derive the indicators for algal bloom prediction and to build early warning models for Lake Taihu.

S12-O Free and Bound Phycocyanin under Highlight Conditions.

A Zaake, A.Dahlhaus, C.Moldaenke

bbe Moldaenke, Germany

In this contribution we will report about our investigation concerning the role of phycocyanin (PC) in bound and unbound conditions. We were looking at the energy transfer from phycocyanin to the chlorophyll and reaction centers. For this purpose the newly introduced bbe PhycoLA was supplied. This instrument uses eight LEDs with varying wavelength to excite specific pigments in algae. It uses the detection wavelength of 650 and 700 nm. Using this instrument we investigated the extent of the energy transfer of PC under bright sunlight conditions in the lake Taihu. With the help of bench top experiments the dependency on UV light was specifically investigated, in particular its role as a driving force for the release of toxins and tastes and odor products under natural conditions.. Results will be presented.

S12-O Unraveling the sources and optical composition of dissolved and particulate organic matter in Lake Taihu.

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Organic matter (OM), as a provider of nutrients, plays an important role during the outbreak of algal blooms in lakes. While many studies on inland lakes in China have investigated the optical compositions and sources of dissolved organic matter (DOM), few studies have simultaneously studied both dissolved organic matter and particulate organic matter (POM), and considered their optical compositions and sources. Therefore, we studied Lake Taihu, a large, shallow and eutrophic lake in China, and monitored 32 sites in autumn and winter 2014, and spring and summer 2015, and applied the combined POM-DOM parallel factor analysis (PARAFAC) model for the first time. There were notable differences in optical compositions and sources between the POM and DOM. The temporal-spatial distribution of the fluorescence indices and principal component analysis (PCA) suggested that the POM in Lake Taihu was mainly from autochthonous sources, and river mouths had more exogenous characteristics than other regions. The chromophoric DOM mainly displayed autochthonous characteristics. The PARAFAC identified five components: three protein-like components (C1, C2 and C5), a microbial humic-like component (C3) and a terrestrial humic-like component (C4). The POM was dominated by C5 in summer and autumn, and by C3 in winter and spring; DOM was dominated by protein-like components (C1, C2 and C5) during all seasons. The algae-dominated region had a higher relative contribution of tryptophan-like components of POM than the macrophyte-dominated region. Dynamic exchanges between DOM and POM play critical roles in organic carbon cycling, interactions with aquatic organisms, bioavailability of pollutants, and aquatic phenomena such as eutrophication. A conceptual model based on the theory of “four phases of cyanobacteria bloom development” was proposed to fully describe the relationship between POM-DOM exchanges and cyanobacteria bloom development.

S12-O Molecular detection of denitrifying bacteria and N-transformation processes in Lake Tai.

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Worldwide, agriculture is the most extensive anthropogenic source of nitrate to surface water and groundwater systems. The lake Tai is an extraordinary example for high eutrophication due to high loads of nitrogen and phosphorus into the lake. A consequence is the decrease of the surface water quality and thus the impairment of the drinking water quality. Microbial denitrification is the key process involved in natural attenuation of nitrate and thus able to improve the water quality. This study focuses on the assessment of heterotrophic denitrification as ecosystem service to naturally attenuate nitrate. Therefore, molecular methods were developed to monitor the extent of microbial nitrate degradation in ecological systems. Denitrifying bacteria from contaminated samples taken from the Lake Tai were cultivated and grown in batch experiments. Ion chromatography was used to analyse the degradation of nitrate to nitrite as the first step of denitrification. To analyse the denitrification process on a molecular level, standards were developed and extraction methods adjusted. The transcription levels of mRNA (narG, nirK, nirS, nosZ) encoding enzymes involved in denitrification were quantified by quantitative polymerase chain reaction (qPCR). In addition these measurements were accompanied by the analysis of the isotopic fractionation factor. Results of the degradation experiments show that the analytical results correlate with the transcription levels of the functional genes and therefore indicate this technique as a suitable monitoring method of active denitrification. Furthermore, samples were taken from different locations around the northern lake Tai during different seasons. These samples were analyzed for their denitrification potential (gDNA) as well as their gene expression (mRNA). The study will help understanding natural attenuation in contaminated sites and will provide a quick screening method for potential denitrification.

S12-O Wetland Ecological Restoration Using the Near-Natural Method. *Ye Chun, Li Chun-Hua*

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Wetland restoration is increasing because many natural wetlands have suffered great loss and degradation. Eco-cities harmony with nature is considered an essential goal for sustainable development across the world. Among different methods for wetland restoration, the ‘near-natural’ method of ecological restoration has been widely proven to be an effective method of eco-city construction in practice. The development history of the near-natural method was reviewed. The nature and properties of the near-natural method were summarized. The differences between the near-natural method and constructed wetland method were analysed. At the same time, the phenomena and origin of pseudo-ecological engineering were presented. Finally, Zhushanhu wetland ecological restoration was used as an example to illustrate the design process of the near-natural method, and the ecological restoration results showed that this method is more effective, sustainable, and longer lasting than other methods. This method is a practical prospect.

S12-O The spatial distribution and bioaccumulation of mercury in size-fractionated plankton from Taihu Lake: algal density as the key driver. *Rui Wang, Pengwei Li, Daqiang Yin*

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Mercury (Hg) is a global contaminant, which could be biomagnified along food chain transfer and pose high health risks to aquatic biota. In the present study, we sampled water and

size-fractionated plankton from 17 sites located in Taihu Lake, to investigated the spatial distribution and bioaccumulation of Hg in this hypereutrophic lake. We observed the spatial distribution of Hg in water was positively related with algal density, likely attributed to concurrent anthropogenic input of nutrients and pollutants. We further investigated the structure at the base of food web in Taihu Lake, by analyzing the stable nitrogen ($\delta^{15}N$) and carbon isotopes ($\delta^{13}C$). The $\delta^{15}N$ values of the size-fractionated plankton collected from different sites were generally higher along the lake shoreline than the central lake sites, suggesting the anthropogenic impact. However, the estimated trophic level of large-size zooplankton (>500 μm) showed no differences among sites, indicating zooplankton are feeding on plankton with different $\delta^{15}N$ baselines. The bioconcentration factor (BCF) of Hg in plankton exhibited negative correlations with algal density, due to biomass dilution effect. The trophic transfer potential of Hg from phytoplankton to zooplankton also showed negative relationship with algal density, likely driven by growth dilution effect. Our findings suggest that the unevenly distribution of phytoplankton is the key driver of the spatial distribution of Hg in water phase as well as the bioaccumulation in plankton, and higher algal density could decline Hg bioaccumulation and trophic transfer at the base of aquatic food webs in Taihu lake, thus might decrease the potential health risks of Hg to biota (e.g., fish) at higher trophic level.

S12-P Fuzzy integrated index for evaluation of macrophytes rehabilitation on nutrients control in an lakeshore restoration, Taihu Lake, China.

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Lakeshore restoration is used to reconstruct the landscape and ecology in littoral zones which have been contaminated or modified by anthropogenic activities, especially in lakes which have experienced eutrophication. The status of these restored lakeshores was evaluated by using a fuzzy integrated assessment method (FIAM), which consisted of 16 physicochemical and biotic indicators. The weights of indicators were calculated using an analytic hierarchy process (AHP). This study took as a case study a lakeshore restoration project in Gonghu Bay, a typical eutrophic lake in China, where the lakeshore landscape has been restored after substrate reconstruction and macrophyte rehabilitation. The FIAM highlighted the status of lakeshore ecology, a multidimensional subsystem containing properties of water, sediment and macrophytes, allocating membership of sites to ‘high’, ‘good’, ‘moderate’, ‘poor’, and ‘bad’ classes. The results indicated that the restored lakeshore with more manual intervention (Zone A) showed a significant improvement on its overall status from good in 2014 to high in 2016. The restored lakeshore based on natural evolution (Zone B) increased from moderate in 2014 to high in 2016, but with some aspects of recovery were undesirable. Human intervention in macrophyte rehabilitation had the advantage of keeping various macrophytes alive in the short term, giving them the opportunity to adapt to a slightly contaminated environment.

S13. Long term dynamics of lake social-ecological system in past, present and future

S13-O A millennium history of limnological responses to anthropogenic disturbances in central China.

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Anthropogenic pressure derived from environmental stressors, such as lake eutrophication, heavy metal pollution and hydrological regulation, are known to threaten ecosystems health. In the context of millennium-scale climate fluctuation, however, little is known about the long-term response of lake biota to the combined impact of anthropogenic disturbances. A eutrophic and metal-contaminated lake, located in the middle reaches of the Yangtze River in central China, was selected for sediment analyses for identifying the role of anthropogenic stressors on limnological changes and community shift. Multiple proxies (heavy metal, geochemical proxies, grain size, X_{lf} and cladocerans) from a 110-cm long sediment core were analyzed. According to the ^{137}Cs and AMS ^{14}C dating results, the sediment core can provide continuous information on ecological changes over the last millennium. Particularly, heavy metal and X_{lf} records show that the lake experienced heavy metal input and catchment disturbance for centuries, corresponding well to the documented history of smelting events. TOC and TN results showed a temporal trajectory of nutrient enrichment before 1950 and the process of lake eutrophication has accelerated after 1990s. The grain size results also showed hydrological regulation may have led to hydrodynamic reduction after the 1850s. Cladoceran assemblages showed a clear trajectory of community shift over the sediment core, which was predominated by planktonic bominids (i.e. *Bosmina longirostris, B. longispina*) with littoral taxa commonly found but often with low abundances. The oligotrophic *Bosmina longispina* was dominant below the core depth of ~80cm, and thereafter was replaced by *Bosmina longirostris*, which often occurs in nutrient-rich waters. After ~1990 A.d., *Bosmina longirostris* decreased obviously with a concurrent increase in littoral cladocerans. Multivariate analyses further indicated that community shift of biotic assemblages over time was mainly attributed to water quality (i.e. nutrients, heavy metals) over the last millennium, while hydrological regulation more recently became a dominant force.

S13-O Network skewness quantifies loss of resilience in human-impacted lake ecosystems.

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Human pressures threaten the stable functioning of the Earth system, yet we still have poor understanding of how real ecological communities respond to disturbance by external stressors. Consequently we lack knowledge of the extent of structural disruption to modern natural systems, and what this means for community composition and functionality. Network theory of self-organised stable states predicts that nodes of similar type will tend to show positive skewness in the distribution of their connections. Engineered systems, in contrast, tend to have lower skewness. Here we analyse a community of algal species (diatoms) found in Chinese lakes to test the hypothesis that external stressors will reduce the skewness of the ecological network, with the amount of reduction indicative of the strength of disturbance and loss of resilience. We constructed a statistical network of diatom communities from a dataset of 452 species occupying 273 lakes across China. We find a tendency for positive skewness in the frequency distribution of diatom species degree in regions with low levels of human impacts, particularly in the rural west of China. Skewness reduces in more impacted regions, and shifts into a predominance of negative skewness among lakes in the most highly disturbed regions, particularly in the industrial east. This skewness change in disturbed lakes relates strongly to the level of nutrient loading from

agricultural activity and urbanisation, as measured by total phosphorus in the lake water. We applied diatom associations from the modern network to sediment core data from five lakes with different historical levels of recent human disturbance. Our reconstructions of network skewness through time show that it weakens with temporal intensification of human impacts in the lake and surrounding catchments and strengthens as lakes recover from disturbance. The appearance and degree of skew present quantitative proxies for the loss of community resilience to exogenous forcing.

S13-O A lake of two stories: insights from multi-basin paleolimnological studies for evaluating social-ecological system shift.

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With societal and catchment development, freshwater systems have been increasingly modulated with significant ecological consequences. However, it is well known to limnologists that ecosystem changes can vary strongly depending on lake typology and land use types, potentially causing spatio-temporal heterogeneity in the trajectory of ecological shift and the properties of ecosystem changes (i.e. resilience, threshold, nonlinearity) within lakes. Here, we presented case studies from two lakes of Southwest China, through sediment records from multiple basins at the same lake, showing the existence of spatial heterogeneity in the forcing of environmental drivers and temporal asynchrony in the dynamic properties of ecosystem shifts within each lake. We firstly revealed the temporal pattern of limnological changes over the last century at local scales. Our results implied that human disturbance has accelerated during the past few decades and the major multiple stressors included eutrophication, hydrological regulation and fisheries. Hydrological regulation and fishery activity were further identified to play a differential role in driving ecological shift at different lake basins. The spatial heterogeneity of their ecological consequences was evidenced in the comparison of temporary trajectories of our biological records at each lake. Within each lake, multivariate methods were applied to quantify the threshold of community shifts, and to reveal that dynamic properties of ecological shift could differ strongly along the environmental gradients within the same lake system. Overall, this presentation suggests that lake typology and land use type should be considered to provide an integrated perspective in the evaluation of socio-ecological system shift and the design of safe operating space for highly impacted lakes

S13-O Cadmium and other trace element accumulation over the last century in northeastern China lakes.

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The flux of several chemical elements in the environment has been heavily modified by a range of human activities such as coal combustion, mining, smelting and agriculture. China has been one of the fastest growing economies of the late 20th and early 21st centuries, which has led to a dramatic increase in the release of potentially harmful trace elements (PHTE) into the environment. As an important heavy industry and agricultural base, northeastern (NE) China

underwent the same process as the rest of the country. The region also experienced large-scale landscape modification for agricultural purposes to support the exponentially increasing population.

Surface cores were collected from 11 lakes in NE China to reconstruct changes in PHTE inputs as tracers of human activities. In each profile, most PHTE enrichment factors do not differ significantly from the pre-industrial values (EF < 1.5), except for Cd (EF = 2-5.5). Radiometric dating of the cores (^{210}Pb, ^{137}Cs) showed that Cd contamination started from the mid-20th century and sharply increased in the 1980s', a pattern that matches the rapid economic and industrial growth of China. Detrital material accounts for a large part of the PHTE supply to the Songnen Plain lakes. Comparison with other records in China suggests that a large part of the anthropogenic Cd in these lakes is likely local in origin. While the Cd inputs probably originate from a combination of sources, an intensification in agricultural practices, through the use of P fertilizers, manure and wastewater would explain these discrepancies between records. These findings highlight the importance of local factors on the Cd geochemical cycle in China. The large anthropogenic component of the Cd inventory compared to other PHTE and its high toxicity indicate that it should be prioritized in future environmental management.

S13-O A multi-proxy approach of testing the dynamics of long term ecological resilience of the floodplain lake systems in Australia and China.

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The large river basins of the world are central to human civilization. Over the millennia the healthy water and ecosystems have generated a wealth of goods and services to the society. However, the global demands for aquatic ecosystems will continue to grow with increasing human populations and decreasing freshwater resources. Sustainable management of aquatic ecosystems is essential for resilient floodplain systems to meet the long term water and food security issues worldwide. The River Murray in Australia and the Yangtze River in Australia are historically important river systems which have supported human civilization over the 40 millennia. Lately, both river basins have been intensively modified for provision of food and water resources to meet the growing demands of riparian populations. In Australia, the influx of European immigrants during the early 20th centuries has caused widespread implications for diversity and ecosystems of the River Murray system. Alteration of natural flows due to river regulation has largely modified downstream agro-ecosystems and associated river health. The 1920s river regulation in River Murray system has led to permanent modification of water quality, riparian floodplain ecosystems and biodiversity. Although having a long history of civilization, the middle and lower reaches of the Yangtze River system have only gone significant modifications of aquatic ecosystem health following the 1950s. Population growth, industrial development and land reclamation for agriculture are the major drivers. This study identifies major events in the past that were catastrophic to aquatic ecosystems health and long term ecological resilience of the both river systems in Australia and China by using a range of multi-proxy approach including sufossil assemblages of zooplankton and freshwater gastropods as well as changes in geochemistry profiles in sediments of floodplain lake systems of Australia and China.

S13-O Lake ecosystem shift caused by social-economic transitions: case from Yangtzer River Basin, China.

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Globally, many freshwater lakes have undergone rapid degradation over the past century. Lake scientists and managers are struggling with enhancing lake ecosystem resilience to cope with escalating anthropogenic pressures. A better knowledge on how lakes and social systems evolved up to the present is vital for understanding, modeling and anticipating the current and future ecological status of lakes. By integrating paleoenvironmental, instrumental and documentary sources at multi-decadal scales, we demonstrate how typical shallow lake socio-ecological systems evolved over the last century in the Yangtze River Basin, a biogeographic region containing hundreds of shallow lakes. We find that an abrupt ecological shift, expressed as a significant reorganization of lake aquatic species and communities, occurred around the AD 1970s. Land reclamation, hydrological modification, and pollution seem to have acted directly and synergistically to cause this shift. We argue the lake socio-ecological systems went through three stages as society transformed from a traditional agricultural to an urbanized and industrialized society. The dominant feedback has changed from conventional farmer-ecosystem feedback to newly formed socio-economic and ecosystem feedback, due to increasing population, social wealth and resource demand during the last decades. Our results highlight the importance of accounting for the long-term dynamics and feedbacks between ecological, social and economic changes when defining safe operating spaces for sustainable freshwater ecosystem management.

S13-P Current status and population trends of wintering whooper swan (*Cygnus cygnus*) in South Korea.

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The Wintering Waterbird Census of Korea began in 1999 at 69 monitoring sites and now 200 major migratory sites are monitored in South Korea. Waterfowl count data have been accumulated from this national program, however, only a few studies have analyzed the temporal patterns of waterfowl communities. The whooper swan was designated as a national monument (No. 201-2) and is protected as an endangered species in South Korea. In this study, we analyzed population changes of wintering whooper swan (*Cygnus cygnus*) at 79 monitoring sites from 2001 to 2018. The average number of whooper swans was 4,296 ± 42.66 and there was an increasing population trend across the survey period ($B = 75.02$, $R^2 = 0.37$, $p < 0.05$). We found that populations in the Nakdong River Estuary, one of the major wintering sites over 18 years (26.22%), rapidly decreased (-0.77% per year). Conversely, whooper swan populations in the Junam Reservoir and Sihwa Lake increased (+1.64%, +0.54%). We assumed that wintering whooper swans made a local migration due to the recent degradation of feeding habitats in the Nakdong River Estuary and the increase in plants used for food (e.g., lotus) in the other inland reservoirs (i.e. Junam). To better understand the complex factors that can cause rapid changes to wintering waterfowl populations, it is necessary to integrate the data from the Bird Census program to conduct in-depth pattern analyses over long-term, national scales.

S14. Macrophyte vegetations of the future

S14-O Aquatic plant traits in Mediterranean streams of different flow regimes.

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Intermittent and ephemeral streams are widespread ecosystems across all continents. Drought events are frequent in streams of semi-arid Mediterranean regions, like Cyprus, in which only 15% of the total length of streams has perennial flow. The ecological significance of intermittently flowing streams has only been recognized recently and still challenges management practices. In Cyprus, the national stream typology has been modified to consider flow regime as a main factor shaping stream communities. However, the effects of flow regimes on aquatic plant traits remained unexplored, hampering our understanding of the links between drought and stream function.

In this study, we have the following hypotheses: i) drought acts as environmental filter to the local species pool and along with local abiotic factors, determines plant communities assembly; ii) in perennial streams plant communities are characterised by rooting plants with rapid reestablishment after hydrological disturbances; iii) plants with desiccation-resistant traits will dominate in the intermittent streams; and iv) traits related to aridity and high light intensities will prevail in harsh intermittent. To evaluate that, we conducted an extensive field sampling in Cyprus. We sampled 171 streams reaches with contrasting flow regime (i.e. perennial mountain, intermittent and harsh intermittent) during spring and summer of 2016 and 2017. We recorded 123 aquatic plant species (vascular plants, bryophytes, and macroalgae) and geomorphological characteristics from the wetted and the temporarily exposed part of the channel. Results from the Principal Component Analysis confirmed our hypothesis that flow regime is the most important factor driving differences among streams. The assigned traits describing morphology, regeneration, dispersal and ecological preference to the aquatic plant species allowed us to determine the adaptive significance of plant communities under drought conditions. Our study provides insights to better understand the effects of drought on aquatic plant communities and function, and thus helps to effective water management.

S14-O Warming effects on aquatic plant-consumer interactions.

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Submerged aquatic plants provide vital functions in shallow aquatic ecosystems by maintaining a clear water state and sustaining high biodiversity. However, aquatic plant abundance and diversity have declined in many shallow lakes due to human activities. Eutrophication has been perceived as the main driver of these plant declines, whereas climate change might further exacerbate the decline of aquatic plant abundance. Herbivory can have a large impact on aquatic plant abundance. However, warming effects on aquatic plant-herbivore interactions remain largely unexplored. We cultured multiple aquatic plants under different temperatures, measured plant chemical traits and quantified plant palatability by pond snails *Lymnaea stagnalis*. We found that rising temperature increased aquatic plant growth in all species, but the effects on plant nutrient content and stoichiometry, and plant palatability were species-specific. Furthermore, we tested the effects of temperature on plant consumption rates by the snails, results showed that the snails increased plant consumption as temperature increased, and the consumption rates increased faster than plant growth rates as temperature increased. Therefore, we conclude warming will lead to a stronger top-down grazing pressure by aquatic herbivores.

Furthermore, most aquatic plant-eating animals are omnivores. There is a trend of increasing proportion of plant consumption towards lower latitude in omnivorous fish communities. Temperature might be a driven factor underlying this trend. We performed diet-selection feeding trials on pond snail, simultaneously offered both animal food and plant material. And results showed that snails at high temperatures increased herbivory after 17 days. In a literature study, we found that rising temperature increased herbivory in multiple taxa of aquatic omnivores, including

fish, tadpole, crayfish and copepod. These indicate that warming might impose stronger top-down grazing pressures on aquatic plants than we anticipated, not only by aquatic herbivores, but also by aquatic omnivores.

S14-O Contrasting responses of function traits in 15 aquatic plants to two water depths: A mesocosm study.

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Water depth is one of the most important factors influencing aquatic plants community structure and distribution, especially in eutrophic lakes. Aquatic plants, which are closely related to water, could exert influential effects on the shallow lake ecosystem. A 50-day mesocosm study was conducted to elucidate the changes of functional traits (plant height, plant biomass and etc.) of aquatic plants between two water depths (50cm and 100cm) in a eutrophic experimental mesocosm. We aim to focus on 1) the trade-offs between the vertical growth and horizontal expansion among 15 species of aquatic plants and 2) the responses of functional traits of different aquatic plants to water depth. These species consist of two life forms: submerged and emergent plants, among which four species had both submerged and aerial leaves. We found that aquatic plants tend to produce smaller ramet number and, for most of selected species, produced larger plant height in deeper conditions than in shallow conditions. There are to some extent trade-offs between the vertical growth and horizontal expansion for aquatic plants; for example, the total sum of ramet height are closely correlated with the total sum of stolon length. The trade-offs are also species-specific Submerged individuals of *Potamogeton wrightii* had better performance in vertical growth than other species, and *Plucens* produced the largest stolon length. In conclusion, our study provide the insight for the adaptation of aquatic plants in eutrophic shallow lakes.

S14-O Vertical biomass distribution in six macrophyte species from different lakes with variable eutrophic gradient in the southwestern Yunnan-Guizhou plateau.

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Submerged macrophytes are a fascinating group of plants especially due to their ecological functions, which form the critical components of shallow lake ecosystems. The mass allocation of submerged macrophytes is a key response for macrophyte survival to eutrophication. To study how macrophytes allocate biomass along the vertical distribution in response to varied eutrophic conditions, a field investigation was conducted on six macrophytes species *Potamogeton perfoliatus, P.wrightii, Stuckenia pectinata, Myriophyllum spicatum, Vallisneria natans* and *Chara globularis* to determine the vertical distribution of biomass across the water column in different lakes. The species were collected from eight lakes in the Yunnan-Guizhou Plateau, southwestern China. The samples were divided into 20 cm-long segments across the water depth and the stem biomass, leaf biomass, leaf and ramet number were recorded. Submerged macrophytes have

shown great plasticity in vertical biomass allocation. Our study discovered a species specific response of biomass allocation of submerged macrophytes to eutrophication. *Stuckenia pectinata* has evidently shown an increase in biomass towards the water surface as nutrient levels rise while no such pattern was observed for *P. perfoliatus*. This study will be useful in guiding decisions on species choice for lake restoration and plant conservation.

S14-O Adaptive plasticity of some typical aquatic plants and their evolutionary insights.

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The adaptive plasticity is crucial in the evolutionary process of many aquatic plants, due to their very distinctive and changing environment. As there are many aquatic plants in the world, the mechanisms and aspects of adaptive plasticity are also very diversified. Based on different taxa, different development stages and different habitats, the strategies of adaptation are very different. We represent some adaptive ability in three different developing stages (seedling, growth, breeding) of some typical aquatic macrophytes (*Potamogeton* species, *P. maackianus*, *Vallisneria natans*, *P. malaianus*) to illustrate how aquatic plants react when facing the changing and stressful environment in different aspects. According to an *in-situ* germination experiment of *P. maackianus* seeds in different water depths, we found that water depth where seeds matured are exactly the most suitable germination water depth for this submerged macrophyte. After that we recognized the breeding characters affected by water depths. We found there were a trade-off between sexual and asexual breeding system in this species. Then wen found an adaptive character of *P. malaianus* in different environmental stress. So wen can conclude the adaptive strategy of aquatic plants is very diversified.

S14-O Effects of high nitrogen on submersed macrophytes: pond experiments.

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Due to excess nutrient loading, loss of submersed macrophytes is occurring world-wide in shallow lakes. In addition to phosphorus, nitrogen has received increasing attention for its contribution to macrophyte recession. The understanding on how high nitrogen concentrations affect growth of submersed macrophytes is still limited, particularly under natural conditions. In this study, we conducted whole-ecosystem experiments with rosette *Vallisneria natans* and canopy-forming *Potamogeton crispus* in 10 ponds subjected to substantial differences in nitrogen loading (five targeted total nitrogen concentrations: control, 2, 10, 20, and 100 mg L^{-1}). The results showed that canopy-forming *P. crispus* was more tolerant than rosette-forming *V. natans* when exposed to high NH_4 concentrations. Canopy-forming species tended to form canopy on water surface with sufficient light to produce carbohydrates and thereby partly overcome high NH_4 stress. NH_4 had negative effect on length of *V. natans*, while weak effect on biomass of *V. natans* when NH_4 concentration was lower than 6 mg/L. NH_4 had weaker effect on macrophytes in

growing season than that in low-growth season. Active growth of macrophytes in the growing season enabled them to partly overcome the NH_4 stress. These results may indicate that NH_4 has weak effect on macrophytes in natural shallow lakes with NH_4 mostly are lower than 6 mg/L.

S14-O Efficiency and mechanism of an enhanced ecological floating bio-reactor with substrates for pollution control in hyper-eutrophic freshwater.

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The use of ecological floating beds (EFBs) to control water pollution has been increasingly reported worldwide due to the severe situation of eutrophication in water bodies. More attention has been paid to the purification efficiency improvement of EFBs in hyper-eutrophic water. In the study, an enhanced ecological floating bio-reactor (EEFB) was designed and built to enhance its purification efficiency with an innovative hollow, thin floating bed integrated with substrates of zeolite and limestone. Compared to a conventional ecological floating bed (CEFB) made of polystyrene foam board, the EEFB increased treatment efficiency of total nitrogen (TN), total phosphate (TP), and ammonia nitrogen (NH4+-N) to 63.5%, 59.3%, and 68.0%, respectively. Plant accumulation was the main pathway for TN and TP removal in the CEFB. Microbial degradation played an increasingly important role in TN and TP removal in the EEFB. A higher concentration of nitrogen cycling bacteria was recorded in the EEFB than the CEFB ($P<0.05$), suggesting that the substrates might enhanced the removal efficiency of EEFB by flavoring the growth of microorganisms rather than their absorption effect.

S14-O Anoxic condition in sediment affects the phytoextraction of metals by submerged macrophytes.

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Eutrophication in wetlands is usually accompanied by anoxic condition in the sediment, which is followed by complex chemical and biological processes, consequently affecting the biogeochemical behaviours of metals in the sediment. The present study investigated the effects of anoxia of sediment on phytoextraction of metals and their fractions in the sediment. The experimental results showed that the different dose of sucrose addition can simulate different levels of sediment anoxia at the first experimental phase. Sediment anoxia promoted the phytoextraction of metals in the submerged macrophyte. The content of Cu in pore water and plant tissues showed different patterns compared to other metals, with decreasing content in pore water with sediment anoxic condition. It was concluded that redox condition of sediments could significantly affect the phytoextraction of metals by submerged macrophyte.

S14-O Mechanisms responsible for interactions between macropyhtes and bacteria in a river.

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Abiotic variables can affect plant growth and activity of microorganisms, both directly by modifying metabolism, and indirectly, via changes in interactions with other organisms. Unclear, however, is how the interaction pattern between macrophytes and microorganisms is controlled by environmental factors in running water systems. We collected macrophyte and water samples from a groundwater-fed river to investigate how water temperature (related to the season) and water depth affect growth of macrophytes and the abundance and viability of microorganisms, and thus shape the macrophyte-microbe interactions. Plant height and heterotrophic bacterial abundance incremented with the increase of water temperature and water depth, yet the temporal and spatial variation of macrophytes and bacteria was not in lockstep with any abiotic variable. Our study highlights the dynamic interactions between macrophytes and bacterioplankton in a lowland river, with even comparable low variability of water temperature and depth. Our results imply that in addition to direct effects on macrophyte growth and/or bacterial abundance, water temperature and water depth can indirectly control the interaction via coupling to nutrient availability and other organisms, like bacteriovores, viruses, fish and so forth.

S14-O Studies on Factors causing the decline of submersed macrophytes in eutrophic lakes and macrophyte restoration measures.

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The change of submersed macrophytes in shallow lakes causes the shift of the ecosystem state. Through laboratory experiments, field survey, in situ experiment, and pilot field restoration practice, our research group has made the progress in following aspects:
1.Response of submersed macrophytes on the stress of water nutrient enrichment.
2.The boundary conditions for the restoration of macrophytes in a lake at early stage of eutriphication.
3.Macrophyte restoration measures including whole lake hydrological regulating, harvesting of floating-leaved plants in littoral zone, synthetic technology of selection of adaptive macrophytes, tissue culture, breeding, field colonization, and stablization.

S14-P Effects of water depth induced light intensity on growth of two kinds of submerged macrophytes.

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In restoration of eutrophic shallow lakes, reducing water levels are commonly used to create optimal light conditions for the colonization of submerged macrophytes. However, the effects of light availability caused by water level fluctuation on submerged macrophyte community remain

ambiguous. In this study, an outdoor mesocosm experiment was conduct to explore the effects of light intensity on submerged macrophyte communities which were constituted by both species with distinct photosynthetic characteristics - *Vallisneria natans* and *Myriophyllum spicatum*. Twelve Mesocosms were placed in one pond along a water depth gradient (50, 150, 250 cm) to create different light conditions. Our results showed that both macrophyte species favored moderate light treatment (water depth: 150 cm), with highest values of plant biomass, height and relative growth rate (RGR) in this water depth. High light condition significantly inhibited the growth of *V. natans*, with RGR, plant biomass and height were all lower in water depth of 50 cm than 250 cm. For *M. spicatum*, low light availability (250 cm) significantly reduced plant biomass and RGR, although the average plant height was increased. From the macrophyte community perspective, the biomass ratios of *V. natans* to *M. spicatum* were positive related to water depth, indicated that the dominance of *V. natans* were increased with the increment of water depth. Our study suggests that water level should be adjusted within a certain range of light penetration when reducing water level is conducted to increase water clarity in eutrophic lake restoration. Although low water clarity may inhibit the growth of submerged macrophytes, high dominance of canopy species, e.g., *M. spicatum* may appear if water transparency is too high.

S16. Monitoring and management of the African Great Lakes

S16-O Multi-Lakes Monitoring of African Great Lakes.

Pierre-Denis Plisnier

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Major African Great Lakes (Albert, Edward, Kivu, Malawi/Nyasa/Niassa, Tanganyika, Turkana and Victoria) harbour the world's richest lacustrine fish fauna. Their fisheries are productive and sustain more than 50 million people. Those lakes are under serious climate and anthropogenic threats. For lake managers, data (fisheries, climate, water quality…) are needed to guide management measures to adapt to climate changes and decrease, whenever possible, unfavourable human impact on the Great Lake environment. However, those data are often lacking or not continuous. For each lake, a long-term monitoring is needed to help managers to better identify changes taking place and propose adaptation measures for the measures to be taken by the Authorities.

There is an added value to monitor those lakes using a multi-lakes approach. Acquired experience from one Lake may have a levering effect for a better understanding of other lakes. Indeed, the lakes limnological cycles are closely linked to climate variability and changes such as wind patterns or rainfall. The lakes are often also under similar types of anthropic pressure (overfishing, deforestation, increased sedimentation, pollution, invasive species…). The experience gained from one lake may be useful for other lake's manager and lead to a wider comparable view of changes taking place at a regional level. Networking of the lacustrine community could also lead toward better harmonized methods for lake monitoring (fisheries, water quality, biodiversity…) and ease their management. The development of common services for all major African Great Lakes could include remote sensing as an important tool particularly for meteorology, limnology and land use. Increased training and public awareness of threats affecting the Great African Lakes at a regional level should be encouraged. Given the considerable ecosystems services that the Great Lakes of Africa are providing, efforts are urgently needed to insure their sustainable use and conservation. A long-term multi-lakes monitoring program is highly recommendable.

S16-O Combination of multi-source altimeter measurements for tracking water level changes of the East African great lakes.

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East African lakes are of great interest due to their significant water resources value but also as an important indicator of climate change. The knowledge of the lake level variations in time over a long period is crucial in understanding the hydrological and climatologic related to the water and energy cycles. Unfortunately, continuous in-situ water level observations in this region are extremely scarce and limited, which make it difficult to observe water level changes. In recent years, satellite altimetry offers exciting new opportunities to monitor temporally continuous information of lake-level. Against this background, the main goal of this study is to track past two decades changes (1992-2012) of water level in the East African great lakes (i.e. Lake Victoria, Lake Tanganyika and Lake Nyasa) through combination of multi-source altimeter data. We propose a set of water level retrieval methodology to obtain quality measurements, including data selection, waveform retracking and combined adjustment. The results are validated with water level time series derived from available in-situ gauging data, yielding RMS differences between 0.12m and 0.63m and squared correlation coefficients between 0.91 and 0.95. Results demonstrate that water levels of Lake Tanganyika and Nyasa show a dominant annual cycle highly correlated with regional precipitations. However, the seasonal variation of water level in Lake Victoria is not obvious. As to Lake Tanganyika, the highest and lowest value of water level generally appears in April and October. Water level's extreme points in Lake Nyasa, including the highest and lowest value, are delayed for a month. At the inter-annual scale, from January 1992 to December 2012, water levels of Lake Victoria and Tanganyika declined, while those in Lake Nyasa rose. Especially, water levels of Lake Victoria and Tanganyika have dropped markedly (> 20 cm/yr) from 1998-2006. This varying lake level trend is associated with the 1997-1998 El Niño. Finally, other driving factors also have been analyzed to understand the mechanisms behind observed water level changes. This study not only provides methodological reference in deriving long-term water level information by multi-source altimeter data, but also valuable for management of water resources over gauge-sparse regions in East Africa.

S16-O Analysis of water environmental quality and monitoring management in the Great Lakes Basin of East Africa. *Chen Shuang, Zheng Tao*

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With one quarter of the world's freshwater reserves in the three great lakes of East Africa, the rapid growth of the population, urbanization and uncontrolled sewage discharge have caused water environmental problems to become increasingly prominent. In this paper, while thoroughly reviewing the previous research of the water environment of Lake Tanganyika, Lake Victoria, and Malawi/Nyanza, the basic characteristics of the regional water quality were analyzed and summarized based on the monitoring data of the northern district of Lake Tanganyika and the rivers entering the lake. Results show: (1)the pH and dissolved oxygen of the water body are high; (2)the urban rivers is seriously contaminated by domestic waste water discharge; (3) the water quality of the lake is good. It also pointed out that water environment monitoring and management exist following problems: lack of networked water quality monitoring in cross-boundary lakes, weak monitoring capabilities in terms of personnel and technology, and the monitoring and management institutions and mechanisms need to be improved. It is proposed to introduce the low-cost technology of river basin water environment monitoring to help establish a water environment monitoring, early warning and management system and to promote the green development in the great lakes region.

S16-O Seasonal patterns in growth rates of three commercially important pelagic fish species of Lake Tanganyika, Kigoma, Tanzania.

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Understanding fish growth is important for sustainable fisheries management. Even in tropical lakes, seasonal changes in lake ecosystems can lead to temporal variation in factors such as temperature and food resources. In Lake Tanganyika, East Africa, there are strong seasonal patterns in the limnological conditions that are associated with the cool/dry season (May-Sept) and the warm/wet season (Oct-Apr). We explored whether these patterns would influence growth rates of the key pelagic fish species, Lates stappersii and the clupeids Limnothrissa miodon and Stolothrissa tanganicae and improve our understandings on the climate effects to their growth. From 2016 to 2017, a bi-weekly sub-sample of fish was taken from fishermen's daily catches, as they landed and sorted to species level in the laboratory. Biometrics of individuals were collected and otoliths were extracted. Digital scaled photographs were taken by NIS-Element software using Nikon DS-FI1 camera mounted on a microscope. Photos were processed using ImageJ app in order to estimated daily growth rings. Limnological conditions were measured using YSI EXO sonde down to 110 m. Our findings indicated that there were seasonal differences in temperature of the water column within the upper 70 m of the lake. From 70 to 110m depth temperature does not change on the seasonal basis. Oxygen at the surface waters (0-30 m) does not change on the seasonal basis, however, minor changes were observed at depth down to 110 m. Daily growth rates of L. Stappersii differed with seasons; the wet seasons had higher growth compared to the dry seasons. In contrast, the growth rate of Clupeids did not differ on a seasonal basis. Overall, the three species showed slightly different growth patterns between seasons; water temperature and food items are partly influencing the pattern.

S16-O Pelagic food web structure in Lake Tanganyika: a stable isotope study.

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Lake Tanganyika in East Africa is hugely important for the human population of riparian countries. Its ecosystem is threatened by eutrophication, erosion, overfishing and climate change. For understanding better the ongoing changes, the pelagic food web structure of Lake Tanganyika was studied using the stable nitrogen and carbon isotopes ^{15}N and ^{13}C. In 2000-2010 isotopes were determined in almost 700 samples of size-fractionated seston, zooplankton, shrimps, jellyfish, fish, periphyton and submerged plants. Moderate short-term variation was observed in the isotope signatures of the seston. Larger changes over years in zooplankton and fish possibly indicated major changes in lake metabolism.

The pelagic trophic ladder in the isotope signal space was linear and short, and separate from the littoral subsystem. Increments of carbon signature from one trophic level to the next were larger (2-3‰), and those of nitrogen signature smaller (~2‰), than usually observed. The epilimnetic picoplankton fraction and the cyanobacteria-dominated net phytoplankton had low nitrogen signatures typical for nitrogen-fixing organisms, and low carbon signatures. The nitrogen signature of the intermediate nano/microplankton fraction could be 2-4‰ higher. In the hypolimnion, all fractions showed 5-8‰ higher nitrogen signatures. Periphyton and submerged plants had low nitrogen signatures, but much higher carbon signatures.

Isotope signatures suggested that the bigger copepods fed on epilimnetic phytoplankton,

small cyclopoids, copepod nauplii and small shrimps on nitrogen-fixing cyanobacteria, fish larvae on copepod nauplii, and big shrimps, jellyfish, and smaller fish on copepods. Higher nitrogen signatures of bigger fish indicated piscivory, except for Lates stappersii also feeding on shrimps. In Lates angustifrons the carbon signature suggested closer links to the littoral. Among 34 littoral-benthic fish taxa, three algivorous species had isotope signatures close to those of periphyton and submerged plants, while all others, including zooplanktivores, zoobenthivores, omnivores, piscivores and scale-eaters, grouped close to the open water planktivores.

S16-O Gases Pool and Profiles in Lake Tanganyika.

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Lake Tanganyika is the second deepest lake of the world. We reported the dissolved gases profiles in the deep oxic mixolimnion and monolimnion. Permanent stratification with oxic mixolimnion at a depth about 100m, and a deeper depth of monolimnion rich of nutrients and dissolved carbon dioxide and methane, sourced from organic detritus degradation and fermentation. Also controlled by the diffusion, oxidation, and assimilation in the oxic mixolimnion. Nitrogen dioxide and dinitrogen did not accumulate in the mixolimnion and monolimnion, but peaked at around 80m, a very clear denitrification hot depth. A batch mode incubation, with isotope tracer, were conducted to reveal the potential nitrogen transformation, including DNRA, Anammox and denitrification.

S16-O The Seasonal Variation of atmospheric nitrogen deposition and the Impacts of land use in the northeastern Lake Tanganyika.

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Lake Tanganyika, an African Great Lake, is a complex tropical ecosystem that has been subject to extreme climate-related changes in the last century, including seasonal changes in temperature and rainfall, decreased overall annual rainfall, and greater frequency of rainstorms. Atmospheric nitrogen (N) is an important component of the lake's N loading, but how seasonal changes in precipitation and land-use difference affect this loading still needs clarification. A monitoring site was established near the lakeshore at Kigoma and the seasonal features of N wet deposition in the lake was analyzed by monitoring atmospheric N deposition concentrations and fluxes with independently collected meteorological data from March 2013 to February 2014. There was a significant temporal variation in wet N depositions in the study area. The distribution of the annual rainfall into major (March–May 299.8mm) and minor (October–December 343.2mm) rainy seasons translated into 20% and 30% of N deposition. In September and January–February, there was 10% and 12% precipitation, representing 43% and 7% of N deposition in the lake. Nitrogen deposition was highest in September due to farmlands' burning during the dry season (June–August), leading to N accumulation in the atmosphere. The Lake Tanganyika area is still less affected by industrial economic activities, forest deforestation, agricultural activities and the pollution of animal and human excrement in urban and rural areas will eventually affect the water quality of river basin and the nutrient concentration in atmospheric sedimentation. A network of 4

monitoring sites using ion-exchange resin collectors was established to study the spatial patterns of atmospheric nitrogen deposition in the northeastern Lake Tanganyika for the sampling period from 2013 through 2015. The sites were classified into urban, woodland, and agricultural land categories to represent the geographical location and land use characteristics surrounding the monitoring sites. Statistical analyses were conducted to evaluate the spatial variations of atmospheric nitrogen deposition concentration. A higher nitrogen deposition concentration was observed over the urban site than that over the rural sites. The land use characteristics surrounding the monitoring sites had profound effects on the atmospheric nitrogen concentration. In conclusion, the pattern of N deposition appears to be driven by the unique climatic characteristics of the lake basin and to be closely associated with local anthropogenic activities.

S16-O Impact of land use and landscape pattern on water quality in the Northeastern part along Lake Tanganyika, Africa.

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Lake Tanganyika is threatened by environmental pollution due to socioeconomic development and population expansion. Understanding the relationships between land use and water quality is useful for effective landscape planning to protect water quality and implement management practices in Lake Tanganyika basin. This study analyzed relationships between land use and water quality in 16 sub-basins along northeastern Lake Tanganyika at different levels of urbanization. The results showed that different land use types had a significant effect on water quality, and could better explain water quality in urban watersheds than in rural watersheds. The artificial surfaces was strongly correlated with most physicochemical and nutrient variables in urban and rural watersheds, suggesting that artificial surface negatively affected river water quality due to intensive human and industrial activities. Woodland had a positive effect on water quality, indicated by a decrease in nutrient values. Arable land decreased total nitrogen (TN) and total phosphorus (TP) in urban watersheds, and increase TN and TP in rural watersheds due to fertilizer application and livestock farming in less-urbanized regions. The effect of landscape patterns also differed between the urban and rural watersheds, with a stronger impact on water quality in urban watersheds than in rural watersheds. CONTAG was the dominant factor in the sub-basins. In urban watersheds, CONTAG was positively correlated with nutrient variables, indicating that water quality degraded in less fragmented and highly dispersed landscapes. However, in rural watersheds, CONTAG was negatively correlated with nutrient variables, indicating that degraded water quality was positively associated with high connectivity in the rural area. Thus, we found that the pattern of human activities, and not simply their magnitude, affects stream water quality. The differences in the configuration of artificial surface and forest patches between different locations and areas with differing degrees of connectivity can explain the variability in stream water quality.

S16-O Environmental issues of waters in Mwanza Gulf, Lake Victoria, Tanzania: Nutrients, water quality, and trophic status.

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Degradation of water quality caused by eutrophication remains to be the most common problem in global freshwater lakes. As the largest tropical freshwater lake on the earth (by area), Lake Victoria, the most important water resource to the littoral countries, is facing a series of environmental problems. In the presented study, temporal and spatial distribution characteristics of nitrogen and phosphorus nutrients were investigated in Mwanza Gulf, Lake Victoria. The water quality and the trophic states were also assessed according to water quality index and trophic state index, respectively. Total nitrogen (TN) and total phosphorus (TP) were typically higher in the south of the middle and south gulf. Agricultural non-point source inputs and resuspension by mechanical disturbance in the south of the gulf could be the main reasons for this spatial distribution. The nutrients concentrations were generally higher in the dry season than the rainy season in the whole gulf except TN and ammonia nitrogen (NH_4^+-N). Water quality index assessment showed that the water quality in central and southern parts of the Mwanza Gulf were generally medium and poor. The whole gulf presented typical spatial and temporal distribution characteristics of better quality in dry season and north areas than the rainy season and south areas. Tropic state assessment results showed that Mwanza Gulf was light eutrophic, while the north part of the gulf was mesotrophic and the south part was medium eutrophic. Phosphorus was confirmed to be the limiting factor to the eutrophication of the gulf.

S16-O Community-Based conservation areas as a fisheries management tool in the East African Great Lakes: an example from Tanzania.

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The inland fisheries of Africa are a crucial socio-economic resource that employs and feeds many families, which is vital in poverty alleviation and combating malnutrition. While the multispecies fishery in Lake Victoria supports over four million dependants, in Lake Tanganyika, over 1 million people are estimated to benefit either directly or indirectly form its fisheries. However, all the great lakes are experiencing multiple stressors associated with the Anthropocene; such as overharvesting, illegal fishing activities, cage aquaculture, industrial and domestic pollution, climate change, and land degradation which are devastating their ecosystems. The sustainability of the fisheries resources and the lakes' ecosystems hinges on responsible exploitation of the resources and conservation of the ecosystems. There is a need to identify and demarcate all critical habitats and Key Biodiversity Areas (KBA) in all the great lakes to ensure a sustainable future of the lakes and the ecosystem services they provide to humanity. And for the conservation efforts to succeed, the local stakeholders should be involved in the entire decision process; and the local communities should be entrusted with the protection of the demarcated conservation areas. This paper borrows from a model of a community-based conservation area in southern Lake Tanganyika, at Utinta-Msalaba, which can be copied and replicated in other East African great lakes to achieve similar results.

S16-O Emerging partnerships, research, and capacity in the African Great Lakes.

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The African Great Lakes are hydrologically and ecologically diverse, species rich, and directly support millions of people. These lakes, like those of all freshwater systems globally, face a set of challenges that have been studied over many decades. Among these challenges are a lack of coordinated research, a dearth of future freshwater experts, and inadequate resources to facilitate effective management. The African Center for Aquatic Research and Education (ACARE), a newly created non-profit, realizes that research today is about partnerships and networks to share data and ideas. Researchers, scientists, managers, politicians, and academics need to come together, unify the search for solutions to the biggest challenges, and close in on the critical pieces that will answer the ultimate questions we ask about our freshwater resources. This talk will focus on ACARE's proposed long-term, perpetual process of collaboration between freshwater experts globally for the purpose of enhancing and harmonizing research, growing a global network of partners, training the next generation of African freshwater experts, and positively influencing freshwater management and policy on the African Great Lakes.

S16-P Vertical and temporal dynamics of primary production and respiration in Lake Tanganyika.

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Knowledge of the depth-integrated profiles of ecosystem metabolism and drivers that govern metabolism of many African tropical Great Lakes remains limited. Measurements of primary production in Lake Tanganyika have mostly been limited to bottle incubation techniques and were for most cases based on measurements made within the upper mixed later (UML; 0 - 40 m). We quantified vertical and temporal variation of primary production and respiration in Lake Tanganyika up to 100 m. We anticipated that metalimnetic gross primary production (GPP) may to some extent compensate for lower GPP in the epilimnion in periods with low epilimnetic production and high water transparency. We established a monitoring program which consisted of a monitoring buoy equipped with a multiparameter sonde and a weather station that was placed in the northern part of the lake, ~8 km south of Kigoma. The multiprobe measured high frequency data of light (0 and 20 m), dissolved oxygen (DO) and water temperature (0 – 100 m; every 10 m) for a period of three months. A weather station recorded air temperature (°C) and wind speeds (m/s). A Bayesian model with non-linear GPP and ecosystem respiration (ER) sub-models were used to calculate the mean daily rates of ecosystem metabolism. Contributions of biotic and physical processes into changes in DO for each layer were estimated using depth-specific diel oxygen model. GPP and ER were elevated within the lake's UML (0 – 60 m). Epilimnetic areal GPP and ER were generally higher than the metalimnetic and hypolimnetic area GPP and ER respectively. Metalimnetic areal GPP and ER were higher and extended below the thermocline when the euphotic depth was deeper and extended below the epilimnion. Daily areal net ecosystem production (NEP) was mostly negative suggesting that the lake was heterotrophic and thus acted as a carbon sink.

S17. New frontiers in freshwater biodiversity research: state-of-the-art methods and key questions

S17-O Global patterns of freshwater diatom diversity. *Janne Soininen*

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Patterns of freshwater diatom diversity are still poorly understood at a global scale. The central still largely unresolved research questions include: (i) to what extent diatom communities differ between the continents, (ii) how is diatom taxonomical and trait composition related to local environmental factors and climate, and (iii) are diatom responses similar towards environment at different continents, that is, are diatom niches conserved. We examined species and trait composition in stream diatoms along environmental, climatic, and spatial gradients globally using six study regions. We also investigated niche conservation in stream diatoms by modeling species responses to environmental and climatic variables in a set of calibration sites (from the US) and then evaluated the models with test sets (from France, Finland, New Zealand, Antilles and La Réunion). We found that diatom species and trait composition varied substantially in response to local environment, climatic and spatial variables indicating both environmental and historic effect. Species composition discriminated better the geographic regions, while trait composition detected better the environmental gradients. This emphasizes the need to examine different levels of biological organization to gain a deeper understanding of the roles of environment vs. history in structuring communities. We further detected low niche conservation in both environmental and climate models and a lack of consistent differences in niche conservation between widely distributed and regionally rare species and among functional groups. For all species, diatom optima with respect to local and climatic variables varied clearly between the regions. Collectively, these findings suggest that diatoms may be locally adapted to prevailing conditions. We argue that in diatoms, environmental and especially climate models may not be transferrable in space globally but need regional diatom data for calibration because species niches seem to differ among geographical regions.

S17-O Resource Subsidies: Trophic Flux across Ecosystems. *Yixin Zhang, Hongyong Xiang*

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Freshwater and terrestrial ecosystems are linked through donor-controlled resource subsidies, which are the addition of nutrients and materials (detritus and prey). Resource subsidies not only affect consumer communities, but also can explain variation in the strength of trophic cascades. However, while the flux supplies foods for recipient communities to subsidize primary producers and consumers and alter species interactions, harmful contaminants are also propagated to adjacent ecosystems through subsidy movement. In both donor and recipient ecosystems, contaminants cause considerable impacts on ecological processes through damaging ontogenetic development of focal species, decreasing subsidy quantity and quality, restricting population size of consumers. All of which can influence ecosystem functioning. Empirical studies have shown that the dynamics and effects of contaminants relating to subsidies can be affected by numerous factors. Future study to examine the influence of subsidies, including contaminant-specific flux, on trophic position of consumers should consider accessing direct and indirect effects of land-use change and global warming on food web structure in recipient ecosystems, as well as in source habitats.

S17-O Different factors are related to occupancy and abundance of freshwater species in a large lake system.

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Occupancy, abundance and their relationship have been traditional study subjects in ecology and biogeography. Nowadays fresh approaches are used to investigate these relationships. We used species as data points to study how niche position, niche breadth, biological traits and taxonomic relatedness affect across-species variation in occupancy and abundance. We used freshwater diatoms and macroinvertebrates as two study groups of organisms. We collected littoral samples from 81 sites around a large lake system and identified the organisms to the lowest possible taxonomic level. In total, we studied 327 diatom and 117 macroinvertebrate taxa. We collected information on their biological traits and taxonomic relatedness. Using principal coordinates analysis (PCoA), we formed trait and taxonomic vectors describing distances between species. As environmental data, we had site-specific physico-chemical variables, which we used for outlying mean index (OMI) analyses to determine the niche position and niche breadth of a species (i.e. ecological traits). We used linear models to study how biological and ecological traits as well as taxonomic relatedness affect occupancy and abundance. We found that ecological traits, especially niche position, were the main determinants of occupancy for both diatom and macroinvertebrate species. In addition to niche parameters, abundances of diatom species were also determined by biological traits and taxonomic relatedness, whereas abundances of macroinvertebrate species were mainly driven by niche parameters. For both groups, occupancy was better explained than abundance, but abundance was generally related to a wider set of explanatory factors. In general, these results show that species occupancy of two different groups of freshwater organisms is determined by similar factors. The relationship between niche position and occupancy was negative, indicating that the more marginal the niche position, the more rare a species is. This has important implications for species conservation: if rare habitats disappear, rare species are also under threat of extinction.

S17-O Enhancing predictability of primer specificity for enda detection aquatic species.

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Environmental DNA (eDNA) techniques have increased in popularity for single-species detection during the past decade owing to their high sensitivity relative to conventional survey methods. Using primers with high specificity can selectively magnify DNA signals collected from the environment, allowing the detection of rare or newly invasive species. However, the absence of guidelines for primer design may compromise the benefits of eDNA detection by incurring high costs and wasted effort during primer development. In this study, we investigated the relative importance of different primer properties (i.e. 3' stability, guanine-cytosine content, dimer stability) and primer-template mismatch properties (i.e. total number, the type, and position of mismatches) in predicting primer specificity, using seven wetland fish species. Specificity was significantly increased if the 3' end of the primers (the last five nucleotides) had fewer guanine/cytosine (i.e. was less stable) and more mismatches. Generally, all purine-purine and one of the pyrimidine-pyrimidine mismatches (cytosine-cytosine) have greater effects (except at the 3' terminal) on primer specificity than other types of mismatches. Our study identifies primer properties that are critical for designing species-specific primers and should enable cost-effective and routine implementation of eDNA in species detection.

S17-O Different roles for geography, energy and environment in determining three facets of freshwater molluscan diversity across China.

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Current understanding on different facets of beta diversity and their underlying determinants remains limited at broad scales in the freshwater realm. We examined the geographical patterns and spatial congruence of three beta diversity facets of freshwater molluscs across all of China, and evaluated the relative importance of environmental filtering and dispersal limitation underlying the observed patterns. Taxonomic (β-TD), functional (β-FD) and phylogenetic (β-PD) beta diversity were calculated for 212 drainage basins belonging to 10 hydrographic regions using compiled occurrence data of 313 molluscan species. Geographical patterns of the three diversity facets were visualized on maps and pairwise spatial congruence among them was evaluated using regression on distance matrices. Variation partitioning and multivariate regression trees were used to assess the relative importance of different mechanisms underlying beta diversity patterns. Beta diversity maps revealed that geographical patterns of β-TD and β-PD showed strong spatial clustering and were well matched with hydrographic regions' boundaries, while β-FD showed only moderate spatial aggregation. The three facets were only moderately congruent, with over 60% of the variation in one facet remaining unexplained by any other facet. Remarkably, all diversity facets were best explained by the dispersal limitation-related variables with considerable unique effects. Environmental filtering associated with energy gradients also made a large contribution, while habitat availability only explained minor fractions of the variation in beta diversity. At the national scale, β-TD and β-PD were more related to dispersal limitation, whereas β-FD was more strongly associated with energy gradients. Our results suggested that, for freshwater organisms with low dispersal capacity, dispersal limitation may override environmental filtering in driving geographical diversity patterns. However, different ecological drivers were important for each diversity facet. Importantly, rather weak spatial congruence among the different diversity facets stresses the need to incorporate functional and phylogenetic facets into the development of conservation planning.

S17-O Temporal changes in aquatic macrophyte beta diversity and its predictors across small boreal lakes.

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Temporal aspects are crucial when studying global change and effects of human activities on biodiversity. However, this aspect is often underrepresented, especially in aquatic studies. Human activities (e.g. changes in land use) can cause various changes on beta-diversity patterns. These beta-diversity patterns can also reveal the spatial aspect of biodiversity loss or biotic homogenization. We aimed to discover if vascular aquatic macrophyte communities show different patterns in beta diversity in relation to human impacts in different decades. We used

presence-absence data of aquatic macrophytes from different decades from 1940s to 2010s from small boreal lakes that have faced growing human impacts during the last 100 years. We utilized generalised dissimilarity modelling to analyse spatial patterns in total beta diversity, reflecting both species replacement and richness difference. The modelling was independently conducted for different time periods and we used the environmental variables that are widely identified to be key variables for aquatic macrophytes and, in addition, land use variables derived from base maps. Preliminary results showed that the total beta diversity was best explained in the 1970s, when human impact has been intense in lakes researched. Altitude and pH were the most important variables in each decade. As altitudinal gradient in this study area is not particularly steep, position in the landscape, reflecting both connectivity and lake characteristics, probably explains the patterns found in beta diversity. Against our expectations, we found that land use was not particularly important in explaining the beta diversity in our study area. Our findings provide important information for aquatic biodiversity assessment and conservation research in boreal areas and beyond.

S17-O New and traditional methods to determine the impacts of river fragmentation on salmonids.

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River obstacles fragment and alter the hydromorphology of a river, with significant implications for aquatic fauna. Management of river obstacles from a fisheries perspective requires an understanding of their impacts on fish movement, population structure and density.

The aim of this study was to assess the impacts of weirs (<3m in height) on salmonids using both new eDNA approaches and traditional electrofishing surveys. An environmental DNA assay for detecting Atlantic salmon was used to infer the migratory impacts of obstacles. Species-specific primers and a minor groove binding (MGB) probe were designed for the assay, based on the mitochondrial cytochrome oxidase I (COI) gene. Electrofishing surveys were used to establish the density and age structure of salmonid populations in impounded and natural river reaches.

The electrofishing study provided an insight into the local impacts of the impoundments, revealing an overall decrease in Atlantic salmon and brown trout fry in this habitat. Environmental DNA analysis was an effective method for deriving the presence Atlantic salmon above and below river obstacles, and in some instances was more sensitive than traditional methods. This research demonstrates the value of using both traditional and eDNA methods for detecting the local and longitudinal impacts of weirs.

S17-O Global patterns in the metacommunity structuring of lake macrophytes: two analysis levels, regional variations and driving factors.

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Biodiversity variation at the level of metacommunities has received a lot of recent interest, yet general patterns of metacommunity organization remain elusive owing to considerable region specificity in the drivers of community structure among single case studies. We studied community-environment relationships of lake macrophytes at two spatial levels using data from 16 regions across the world. More specifically, we examined (a) whether the lake macrophyte communities respond similarly to key local environmental factors, major climate variables and lake spatial locations in each of the regions (i.e., within-region approach), and (b) how well can explained variability in the community-environment relationships across multiple lake macrophyte metacommunities be accounted for by elevation range, region spatial extent, latitude, longitude and age of the oldest lake within each metacommunity (i.e., across-regions approach). In the within-region approach, we employed partial redundancy analyses together with variation partitioning to investigate the relative importance of local variables, climate variables and spatial location on lake macrophytes among the study regions. In the across-regions approach, we used adjusted R^2 values from the variation partitioning to model the community-environment relationships across multiple metacommunities using linear regression and commonality analysis. We found that niche filtering related to local lake-level environmental conditions was the dominant force structuring macrophytes within most metacommunities. However, our results also revealed that elevation range associated with climate and spatial location was important for macrophytes based on the findings of the across-metacommunities analysis. This finding suggests that wider elevation range leads to increasing temperature amplitude that, in turn, affects macrophyte communities. Additionally, the relationship between elevation range and spatial location is likely related to dispersal limitation. Our findings also emphasize that although single metacommunities may show region-specific patterns, a comparative analysis across multiple metacommunities may result in better generalizations of factors affecting biodiversity.

S17-O Microbial community composition and functional gene diversity vary along a salinity gradient in Xiaochaidan Lake on the Qinghai-Tibetan Plateau.

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Salinity gradient plays an important role in shaping the microbial diversity and function in natural environment. Multiple studies have been performed on microbial variation along a continuing salinity gradient (usually no higher than seawater salinity) in aquatic ecosystems (e.g., estuary). However, limited is still known about how microbial and functional gene diversity shifts along a larger continuing salinity gradient (e.g., up to higher than sea water). Here, we investigated the microbial community composition and functional gene diversity in sediments along a continuing salinity gradient (~0-120 g/L), collected from a hyper-saline Xiaochaidan Lake (total salt: up to 160 g/L) and its feeding river on the Tibetan Plateau, using 16S rRNA gene phylogenetic and metagenomics analysis. Our results showed that: 1) bacterial richness significantly ($P < 0.01$) decreased with increasing salinity; while its archaeal counterpart exhibited significant quadratic correlation with salinity; 2) pH showed stronger influence on bacterial and archaeal distribution than salinity did in samples with salinity lower than seawater (0-35g/L), whereas the trend is opposite in samples with salinity higher than seawater (>35g/L); 3) functional gene diversity significantly increased with increasing salinity; and 4) functional gene compositions associated with carbon, nitrogen and sulfur cycling shifted distinctly along the salinity gradient in this study. Collectively, these findings are beyond what is known for microbial response to salinity change lower than seawater.

S17-O Meta-analysis of zooplankton thresholds and phenology in lakes with different climate by inferential modelling.

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This study analyses 30 years of limnological data of the eutrophic temperate Lake Müggelsee (Germany) and the meso- to eutrophic Mediterranean Lake Kinneret (Israel) including abundances of rotifers, cladocera, copepods, chlorophyta, bacillariophyta, dinophyta and cyanophyta as well as DIN, DIP and TP, and water temperature. The data analysis has been carried out by means of Gradient Forest (GF) and the Hybrid Evolutionary Algorithm (HEA).
GF has been applied to determine the "importance" of gradients in biotic and abiotic drivers for the zooplankton community, and to identify the "strongest responding" zooplankton groups to theses gradients. Results suggest that over the past 30 years the copepods of Lake Kinneret correlated strongest with gradients of cyanophyta, followed by dinophyta, chlorophyta and TP. By contrast, cladocera correlated strongest with water temperature gradients, followed by DIN, cyanophyta and DIP in Lake Müggelsee.

HEA has been applied to data from 1980 to 89, 1990 to 99 and 2000 to 2009 of both lakes to model the copepod dynamics in response to cyanophyta, and the cladocera dynamics in response to water temperature for both lakes. Results for the cyanophyte-driven copepod models of Lake Kinneret reflect the divergent phenologies and gradients of interacting cyanophyta and dinophyta in this lake. The water temperature-driven cladocera models for Lake Müggelsee indicate not only a progressing direct impact of water temperature gradients on the phenology of cladocera in this lake, but also reveal the mismatch between shifted spring peaks of chlorophyta and bacillariophyta from early May in the 1980s to mid-March in the 2000s and cladocera peaks in early May.

Outcomes of this study may suggest that the response of zooplankton communities to environmental and climate changes in lakes with warmer climates tends to a lesser extent be driven by unmediated gradients of abiotic drivers but more by food web mediated gradients.

S17-O Understand microbial biodiversity through the lens of field experiments along climatic zones. *Jianjun Wang*

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Spatial patterns in biodiversity are one of the core topics in ecology; however, the mechanisms driving these patterns remain unclear. Climatic factors, especially temperature, are regarded as the main drivers underlying diversity gradients at broad spatial scales. On the other hand, human impacts, such as nutrient enrichment, have been identified as one of the main drivers of biodiversity loss in recent decades. A promising approach to explore climatic effects would be macroecological experiments (i.e., broad-scale field experiments) on mountainsides. This approach integrates elevational gradients with experimental manipulations of nutrient enrichment to explore the independent effects of climate and human impacts on biodiversity. Here, we conducted comparative field experiments, paralleled in subarctic and subtropical regions, to examine the independent effects of temperature and nutrient enrichment on aquatic bacterial biodiversity and community composition from the taxonomic, functional and phylogenetic perspectives. Bacterial communities allow us to examine diversity patterns in natural field conditions subject to real species pool effects, which cannot be conducted in laboratory conditions, or for macroorganisms, within feasible time periods. For instance, from the taxonomic perspective, temperature plays a pivotal role in maintaining elevational biodiversity patterns but its effects are modified by nutrient enrichment such that temperature effect on richness is strongest at very low or high nutrient levels. The findings offer examples of the importance of the study of global changes using integrating experiments and natural environmental gradients, and illustrate an approach which can be distributed globally to advance our predictive understanding of ecological trends and responses.

S17-O Spatially-explicit species distribution models: a missed opportunity in conservation planning? *Sami Domisch[1], Martin Friedrichs[1,2], Thomas Hein[3], Florian Pletterbauer[3], Annett Wetzig[1], Sonja C. Jähnig[1], Simone* d. *Langhans[4,5]*

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Systematic conservation planning is vital for allocating protected areas given the spatial distribution of conservation features, such as species. Due to incomplete species inventories, species distribution models (SDMs) are often used for predicting species' habitat suitability, however they mostly ignore spatial dependencies in species and predictor data. Here, we provide the first comparative evaluation of how accounting for spatial autocorrelation affects the delineation of potential protected areas. We employ Bayesian spatially-explicit and non-spatial SDMs for 85 fish species in the Danube river basin using sub-catchments as spatial units. We then use the optimisation software Gurobi to allocate potential protected areas across a range of conservation targets (10-90%), and compare the arrangement of spatial conservation plans

between the two modelling approaches. The results show that spatially-explicit SDMs (i) produce on average more accurate predictions in terms of AUC, TSS, sensitivity and specificity, along with a higher species detection probability. Spatial conservation plans that use predictions from spatially-explicit SDMs (ii) require a similar amount of planning units, (iii) but are spatially substantially different, compared to those that use non-spatial SDM predictions. The overlap in spatial conservation plans is smallest for the lowest conservation target, and vice versa. Accounting for the spatial characteristics in SDMs showed to have a drastic impact on spatial conservation plans, and we therefore encourage conservation practitioners to assess spatial dependencies in their data to derive best-possible options for the spatial arrangement of protected areas.

S17-O Microbial functional gene biodiversity shows congruent elevational patterns across Eurasian mountains.

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The study of macroecological patterns is fundamental when assembling local, regional and global approaches to biodiversity evolution and distribution. That constitutes a necessary step to gain insight into factors driving ecosystem processes and functioning and species' response to global environmental change. Until recently, large-scale approximations to biodiversity have been based on the species concept. However, the current global change context has encouraged biogeographers to consider a functional approach in order to reach a more comprehensive knowledge on earth system biology. Together with the latitudinal, the elevational gradient in diversity is one of the oldest known macroecological patterns. Although elevational patterns have mainly pivoted on macroorganisms, the modern development of metagenomics has allowed an increase in microbial macroecology research. Nevertheless, functional genes have been rarely tackled from a biogeographical perspective and the few existing studies concern terrestrial ecosystems. Based on Geochip gene-array, here we investigate: i) elevational patterns in microbial functional gene diversity from three mountain streams located in Norway, Spain and China; ii) their congruence across organism kingdoms and gene categories and families; and iii) main environmental drivers underlying them. We found that functional gene diversity generally decreased with elevation, it being congruent across mountains, gene categories and kingdoms. Elevational distance-decay relationships for all gene categories and kingdoms were strongest in China and non-significant in Norway. Globally, conductivity and temperature were highly correlated with diversity, while geographic location and conductivity were relevant for assemblage composition. For each mountain, the most important variables driving diversity were consistent with those for assemblage composition. Elevational decreasing patterns were remarkably consistent across three mountains for some gene families involved in key biogeochemical processes related to nitrogen cycling and carbon degradation. Our results demonstrate for the first time the existence of clear biogeographical patterns in functional gene diversity from benthic microbes.

S17-P Unexpected Intra-habitat heterogeneity in diversity and composition of Diazotrophic community in a deep mountain Lake.

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Biological nitrogen fixation has been recognized to be an important ecological process in many terrestrial and aquatic habitats. To date, however, there is little information on the diazotrophic diversity, abundance and spatial distribution in freshwater environment. The objective of this study was to examine the variability of diazotrophic spatial distribution and their controlling factors in Fuxian Lake, which is characterized by evident thermal stratification in summer. The high-throughput sequencing and quantitative polymerase chain reaction (QPCR) were used to assess the diversity, abundance and distribution of *nifH* genes in three regions: surface water, euphotic zone (10 m depth) and two stratificated locations (D, 10 layers from 0 to 150 m; P, 8 layers from 0 to 70 m). The results showed that dominated OTUs (>0.1% of all sequences) grouped with *nifH* sequences from Bacteroidia, Cyanobacteria, Proteobacteria (Alpha-, Beta-, Gamma-, Delta- and Epsilon-proteobacteria), and Unclassified sequences. The diazotrophic diversity and abundance found in surface water were higher than euphotic zone (10 m depth). The diazotrophic communities along the surface edge and at the central were significantly different, but the nitrogen-fixing bacterial distribution in euphotic zone was patchy with highest diversity sporadically occurring through the central and northern Fuxian Lake. Two stratified stations (D and P location) were significantly discrepant with higher diversity in P location. Our results suggest that there are differences in surface water, euphotic zone and two stratificated locations and environmental variables including TN, TP, NO_2^-, NH_4^+, and turbidity were significantly related to the spatial variation of diazotrophic community.

S18. Nutrient (N&P) cycling across sediment-water interface and the implication for sediment internal loading management in shallow eutrophic lakes

S18-O Effects of silver nanoparticles on nitrification and associated nitrous oxide production in aquatic environments.

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Silver nanoparticles (AgNPs) are the most common materials in nanotechnology-based consumer products. Due to wide application of AgNPs, their potential environmental impact is a current and highly topical focus of concern. Nitrification is one of the most susceptible processes to AgNPs in the nitrogen cycle, but effects of AgNPs on nitrification in aquatic environments are not well understood. Here, we report the AgNP impacts on nitrification and associated nitrous oxide (N_2O) production in estuarine sediments. AgNPs inhibited nitrification rates, which decreased exponentially with increasing AgNP concentrations. The response of nitrifier N_2O production to AgNPs exhibited low-dose (<534, 1476, 2473 μg L^{-1} for 10, 30, and 100 nm AgNPs, respectively) stimulation and high-dose inhibition (hormesis effect). Compared with control, N_2O

production could be enhanced by >100% at low doses. This result was confirmed by metatranscriptome studies showing upregulation of nitric oxide reductase (norQ) gene expression in the low-dose treatment. Isotopomer analysis revealed that hydroxylamine oxidation was the main N_2O production pathway, and its contribution to N_2O emission was enhanced when exposed to low-dose AgNPs. This study highlights molecular underpinnings of AgNP effects on nitrification activity and demonstrates that the release of AgNPs into the environment should be controlled because they interfere with nitrifying communities and stimulate N_2O emission.

S18-O A historical perspective on changes in sediment bioavailability of anthropogenic phosphorus in Lake Erie.

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Phosphorus is the limiting nutrient for algal activity in Lake Erie and many other lakes around the world. Since European settlement Lake Erie has received more than one million metric tons of P from anthropogenic sources, of which a fraction can be recycled back into the water column, acting as a persistent internal nutrient source for phytoplankton growth. However, the magnitude of this internal flux is poorly constrained. Here we present results from sequential chemical extractions to reveal variations in the distribution of P forms in sediments from Lake Erie during the past 200 years. We found that the sediment bioavailability of P as indicated by nonapatite inorganic phosphorus has increased substantially. Changes in the sediment loosely bound P alone may have induced an increase of 3.3 mg P m^{-2} day^{-1} in the resuspension flux, which is nearly one order greater than previously estimated for the diffusive flux across the sediment-water interface. Consistent with increased trends of biogeochemical cycling and transfer of Fe and other elements during the course of major ecosystem and water-quality changes (pollution, eutrophication, and colonization of dreissenid mussels) over the past halfcentury, the increased bioavailability of P in the internal flux from resuspension may have contributed to recent record-setting algal blooms that occurred in a time when the external flux was reduced considerably. Despite the noted influence of agricultural practices and climate changes on the delivery of stream flow and nutrient loading, our work underscores a vital role of ecosystem changes in modulating the distribution and bioavailability of P, which, in turn, affects the algal productivity of the lake.

S18-O *phoD* and *phoX* alkaline phosphatase-encoding genes in suspended particles in Lake Taihu.

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The mineralization of organic P to orthophosphate in suspended particles by alkaline phosphatase plays an important role in phosphorus cycling in aquatic ecosystem, especially in shallow lake. We identified the the spatial and temporal distribution characteristics of the

abundance of phoD and phoX genes in suspended particles and explored the relationships between environmental factors and the abundance of the two genes in four ecological regions in Lake Taihu, a large shallow eutrophic lake. The qPCR analysis suggested that the phoD gene is the predominant alkaline phosphatase-encoding gene in four ecological regions in the study period and the abundance of the phoD gene was significantly higher than that of phoX gene (6-42 times). The abundance of phoD and phoX genes in suspended particles showed significant difference in spatial and temporal distribution. In June, the abundance of phoX(9.18×10^4copies/L) and phoD(1.88×10^6copies/L) in the river estuaries were the highest, followed by that in macrophyte-dominated zone, Central lake zone and algae-dominated zone. The highest abundance of the two genes in river estuaries was attributed to the introduction of exogenous microorganisms. Compared with the gene abundances in June, the abundance of phoD gene in four ecological regions decreased significantly in September while that of phoX gene increased in algae-dominated zone and macrophyte-dominated zone. In September, the abundance of phoX gene(5.70×10^4copies/L) in macrophyte-dominated zone was the highest and the lowest was in central lake. The influence of environmental factors on gene abundance is complex, showing different effects in different months. Alkaline phosphatase activity (APA) was mainly affected by the abundance of phoX gene and the organisms harboring the phoX gene are different in macrophyte-dominated zone and algae-dominated zone.

S18-O Transformation of Internal Sedimentary Phosphorus Fractions by Point Injection of CaO_2.

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The transformation of sedimentary phosphorus (P) fractions by point injection of CaO_2 was investigated in this study. The results showed that the addition of CaO_2 increased the dissolved oxygen (DO) in the overlying water as well as its pH. Simultaneously, the concentrations of total organic carbon (TOC), ammonia nitrogen (NH_4^+-N), total phosphorus (TP) and dissolved inorganic P (DIP) in the overlying water were sharply reduced by the point injection of CaO_2, indicating that this accelerated the mineralisation rate of organic matter. It also favoured the formation and maintenance of the micro-oxidation environment in the deep sediments. NH_4Cl-P, Fe/Al-P and Ca-P increased significantly, while the Res-P decreased sharply, especially close to the injection point of CaO_2, accelerating the transformation of P. These results can all be attributed to the oxidation of organic P and the adsorption of dissolved P from the overlying water. Additionally, the $NaHCO_3$-extractable phosphorus (Olsen-P) and algal available phosphorus (AAP) were reduced, and their percentages in Ca-P and Fe/Al-P also decreased, especially close to the injection point of CaO_2. The bioavailable P decreased from 25.6% (the initial) to 17.2% (the mean for the different distances) after the point injection of CaO_2, when the sum of the Olsen-P and AAP was used to calculate the bioavailable P. This indicates that point injection of CaO_2 favours not only the transformation of P species but also inhibition of the bioavailable P. This is attributable to acceleration of the transformation from bioavailable to inert P.

S18-O Nutrient ratios and forms drive algal biodiversity; implications for shallow eutrophic lakes.

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Many shallow lakes are becoming increasingly eutrophic, and blooms of cyanobacteria such as *Microcystis* are one of the types of manifestations of eutrophication. In terms of proportions, many freshwater systems are increasingly N-enriched, due to disproportionate efforts to control P,

typically considered the limiting nutrient in freshwater systems. Years of nutrient loading may also result in large sediment reservoirs of nutrients once nutrient loading is reduced. In addition to nutrient ratios, the redox form of N has been recognized to play an important role in shaping the communities of primary producers. Regeneration of N in shallow systems, as well as anthropogenic inputs, can lead to very high levels of regenerated forms of N. This raises important questions about nutrient preferences for those cyanobacteria that are succeeding in nutrient enriched systems, as well as questions about other species are less successful. While increased nutrient load can create new biomass, it takes the 'right' nutrients – the right forms and proportions – to shift biodiversity. Algal biodiversity and emergent dominant algal (including cyanobacterial) communities are a function of differences in the form, amounts and proportions of nutrients that are regulating not only at the limiting end of the substrate continuum, but also at enriched levels where stimulation may turn to repression of key physiological processes. Shifts in N form from NO_3^- to NH_4^+ lead to community shifts away from plankton communities dominated by diatoms to those dominated by flagellates, cyanobacteria, and eubacteria. Toxic cyanobacterial species also appear to be favored over diatoms when N is supplied in chemically-reduced relative to oxidized forms. Here, using examples from different freshwater systems, including Taihu, the effect of the proportion of reduced to oxidized forms of N are addressed by considering not only what stimulates growth (of the cyanobacteria) but what represses growth of the diatoms.

S18-O Effects of multiple antibiotics exposure on denitrification process in the Yangtze Estuary sediments.

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Denitrification is a dominant reactive nitrogen removal pathway in most estuarine and coastal ecosystems, and plays a significant role in regulating N_2O release. Although multiple antibiotics residues are widely detected in aquatic environment, combined effects of antibiotics on denitrification remain indistinct. In this work, 5 classes of antibiotics (sulfonamides, chloramphenicols, tetracyclines, macrolides, and fluoroquinolones) were selected to conduct orthogonal experiments in order to explore their combined effects on denitrification. ^{15}N-based denitrification and N_2O release rates were determined in the orthogonal experiments, while denitrifying functional genes were examined to illustrate the microbial mechanism of the combined antibiotics effect. Denitrification rates were inhibited by antibiotics treatments, and synergistic inhibition effect was observed for multiple antibiotics exposure. Different classes of antibiotics had different influence on N_2O release rates, but multiple antibiotics exposure mostly led to stimulatory effect. Abundances of denitrifying functional genes were inhibited by multiple antibiotics exposure due to the antimicrobial properties, and different inhibition on denitrifiers may be the major mechanism for the variations of N_2O release rates. Combined effects of antibiotics on denitrification may lead to nitrate retention and N_2O release in estuarine and coastal ecosystems, and consequently cause cascading environmental problems, such as greenhouse effects and hyper-eutrophication.

S18-O Nitrogen fixation occurring in sediments: contribution to the nitrogen budget of Lake Taihu, China.

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Nitrogen (N_2) fixation in benthic sediment can contribute some bioavailable nitrogen (N) in aquatic systems. However, data on sediment N_2 fixation have been poorly documented and the contribution of sediment N_2 fixation to the N-budget in lakes has rarely been studied. In this study, N_2 fixation rates in the sediments of Lake Taihu were measured periodically by traditional acetylene reduction assay. The highest sediment N_2 fixation rates occurred in winter with a maximum value of 258 nmol $N \cdot kg^{-1} \cdot h^{-1}$ in Meiliang Bay, and the lowest occurred in all seasons at some sites, with values near zero. East Taihu Bay, Meiliang Bay, and the Southwestern Coast Area were "hotspots" for sediment N_2 fixation activity. The average annual N_2 fixation rate and volume in the sediments of Lake Taihu were 0.083 g $N \cdot m^{-2} \cdot yr^{-1}$ and 195 $t \cdot yr^{-1}$, respectively; the nitrogen inputs were much lower than inputs from river inflow, atmospheric deposition, and sediment release. This study revealed that N_2 fixation in sediments contributed only a minor part of the nitrogen budget, while the contribution of sediment N_2 fixation cannot be ignored in the N budget at sediment-water interface, at least, at a certain area and/or period. The minor contribution of sediment N_2 fixation to the N budget in Lake Taihu may be linked closely to sediment characteristics such as the quantity and quality of organic matter.

S18-O Nitrate removal at sediment-water interface driven by living *Microcystis*.

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Recent studies indicated that the algal decomposition produces particulate and dissolved organic carbon, and can enhance denitrification in eutrophic lakes. Moreover, during cyanobacterial blooms, a large amount of living algae, especially cyanobacteria, could gather at the sediment-water interface. This study explores a new underlying mechanism of nitrate removal which is driven by living *Microcystis*. The results suggested that living *Microcystis* significantly enhanced the nitrate removal at sediment-water interface, with a nitrate removal rate of 0.54 d^{-1}, which was 2.57 times higher than that in control. Measurements of Chl *a* and Fv/Fm confirmed that *Microcystis* was tolerant to dark and /anoxic conditions, and the recovery experiment suggested that it could survive under such stress conditions for at least seven days. Meanwhile, dissolved organic carbon (DOC) secreted by living *Microcystis* reached 4.55 mg C mg^{-1} Chl *a*. These secretions were biodegradable hydrophilic and contained carbohydrates and proteins. Low nitrogen availability could reduce DTN but improve DOC leached from *Microcystis*, and that these organics could contain more carbohydrates and be easily biodegradable. Our study indicated that during blooms, sinking *Microcystis* cells could directly provide DOC as carbon source, and thus enhanced the denitrification at sediment-water interface, and the interactive relationship between living cyanobacteria and permanent nitrate removal should be taken into account while studying nitrogen cycling in aquatic ecosystem. Compared to dead cells, the living cells might have more significant meaning for the nitrogen cycle in eutrophic ecosystems, because they could continuously secrete DOC, and exert a long-term impact on nitrate removal at the sediment-water interface.

S18-O Discrepant reduction efficiency of internal nitrogen and phosphorus loadings by sediment dredging: Evidence from laboratory to field observations.

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Dredging is frequently implemented for the reduction of internal nitrogen (N) and

phosphorus (P) loadings, but with controversial results. Many factors, including the external pollution loadings and residuals during dredging activities, are contributing to minimize the effectiveness of dredging. In the current study, the short- to long-term variations of internal N and P loadings after dredging were compared both through laboratory experiment and field observations. Results showed that the short-term (less than six months) reduction of internal P loadings were better than that of N both in laboratory and field dredging areas. However, the long-term (six months to fifteen years) reduction of internal N loadings were proven to be better than that of P no matter with and without the external pollutions loadings. The deposition of external suspended particulate matter (SPM) was observed to be the major contributor counteract long-term dredging effects rather than the residual matter during dredging activities. The SPM easily adsorbed P in the water and also readily released P after deposition on the sediment due to extensive adsorption of dissolved organic matter (DOM, consisting primarily of easily-decomposed humic-like substances), iron, aluminum, redox-sensitive P, and organic P. The rapid increase in internal P loading resulting from the external SPM enlarged the long-term differences between internal N and P loadings. Therefore, while internal P loadings were more effectively reduced by dredging in the short-term, internal N loading were more effectively reduced long-term under the continuous deposition of external SPM.

S18-O Interactions of riverine suspended particulate matter with phosphorus inactivation agents across sediment-water interface and the implications for eutrophic lake restoration. *Hongbin Yin*[*]*, Cheng Liu*

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Phosphorus (P) inactivation agents (PIAs) have been widely used in lakes for eutrophic management. However, the interactions of riverine suspended particulate matter (SPM) with PIAs have not been elucidated to the point of complete confidence in the success of PIA application to eutrophic lakes. In this study, a long-term field incubation experiment was carried out to investigate the effects of riverine SPM on sediment internal P management. Fluorescence excitation emission matrix coupled with parallel factor (EEM–PARAFAC) was used to characterize dissolved organic matter (DOM) derived from SPM/sediment, and to study its complexation with La (Ⅲ) and Ca (Ⅱ) contained in two PIAs. The analysis identified one protein-and two humic-like components in these samples, which show variable quenching effects by La (Ⅲ) and Ca (Ⅱ). The continuous settling of SPM can bury PIAs deeper into the sediment layers and while increasing the mobile P content in surface sediments. This consequently made an increase of P fluxes and surface sediment reactivity, which was witnessed by the increased labile P concentration measured by diffusive gradient in film (DGT). However, the binding capacity of PIAs towards sediment mobile P was kept in a buried layer during the six months' field experiment. This study indicates that the influence mechanism of riverine SPM on PIAs was through a decrease of the reactive sorption sites of PIAs by complexing with DOM and continuously increasing the mobile P content in surface sediment thereby largely surpassing their maximum P sorption capacity. Repeated dosing at scheduled times would be better for turbid eutrophic lake remediation with high input of riverine SPM in long-term management.

S18-O Sources or sinks - what drives phosphorus retention and re-dissolution in lowland riverlakes? *Marcus Wildner, Markus Venohr*

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Phosphorus, next to nitrogen, is a one of the central macro nutrients, required by primary producers. Many Europeans face an excess of these nutrients. Permanent and temporary nutrient retention, reducing the amount of directly bioavailable phosphorus is consequently an important process, potentially limiting e.g. algae, phytobenthos or macrophyte growh. Phosphorus from external emission and internal re-dissolution from sediments and biomass leads to elevated total phosphorus (TP) concentrations in the water and therefore potentially enable primary production and subsequent eutrophication effects. Extent and combination of involved bio-chemical processes largely depend on the surface water characteristic like depth, temperature, sediment type or flow velocity. Especially in river-lakes (according to the German LAWA-classification) eutrophication dynamics are highly variable, due to their short residence time (< 30 days), low mean depth (often < 3m) and polymictic stratification. Phosphorus balances were derived from inflow and outflow of 29 river-lakes and similar riverine lakes with high flushing rates in the lowland of Northern Germany from the twenty year time period from 1996 to 2015. Several morphological and physico-chemical parameters were considered in statistical analyses to identify drivers of phosphorus re-dissolution and retention with a monthly temporal resolution. Our study showed that different parameters interactively impact the TP-net balance between retention and re-dissolution. Especially, the balances of river-lakes are influenced by various parameters, mainly PO4-P and Nitrogen compounds. Seasonally, in summer periods light limitation correlates strongly with a re-dissolution of phosphorus. Based on these results an empirical approach can be derived for research on water quality and downstream management of lowland river sections stressed by eutrophication.

S20. Remote sensing of inland waters

S20-O High-Resolution Global Lake Dynamics Product Development and Quality Assurance and Quality Control. *Yongwei Sheng*

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Lakes play a crucial role in the global water cycle and are sensitive to global warming and human activities. There clearly is a pressing need to understand temporal and spatial variations of lakes globally. Though essential, quality assurance and quality control (QA/QC) procedures are missing from many regional-scale water body mapping projects. We have produced circa 2000 and circa 2015 high-resolution lake databases in a systematic way to provide a comprehensive assessment on lake dynamics at global scales. Millions of lakes have been mapped out using Landsat images acquired during lake-stable seasons and have gone through intensive QA/QC procedures. A set of highly replicable automated lake mapping methods and tools have been developed to tackle various situations across the entire. Even though these effective algorithms are being used, commission and omission errors still exist and some lake boundaries may not be adequately delineated. These errors need to be identified and mitigated through intensive QA/QC processes. However, QA/QC of such a huge quantity of lakes remains a great challenge. We have developed two QA/QC strategies with automation. Automated QA requires mapping the Earth multiple times in the same seasons for lakes and identifies “inconsistent” lakes for further QC. Other lakes without significant changes are considered quality assured, and labor-intensive QC is only limited to those “inconsistent” lakes. We have also developed semi-automated QC tools to further reduce the workload for manpower. The 2000 and 2015 high-resolution systematically generated global lake database with adequate QA/QC will be released shortly.

S20-O Remote sensing of changes in Tibetan lake hydrology system in response to climate change. *Chunqiao Song[1,*], Yongwei Sheng[2], Linghong Ke[3]*

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High-altitude environment on the Tibetan Plateau has been changing rapidly. Clustering high-altitude lakes showed evident and wide-ranging growths during the past several decades, and serve as key indicators of changing hydrologic and cryospheric systems. Monitoring of Tibetan lake dynamics is of vital importance, but bathymetric and water-level data are scarce due to logistical constraints of operating gauges and lack of data sharing. Remote sensing provides an effective way to fill the gap, but long-term and fully covered monitoring of lake volume changes in ungauged basins is a grand challenge that has not yet been solved. However, the availability of optical remote sensing images, satellite altimetry data, and gravimetry data makes it possible to monitor the overall variations in lake water storage in this extensive region. Based on the statistical relationships between the lake surface areas and water levels, we established an empirical model for each lake beyond certain size to reconstruct time series of lake levels without altimetry records for each lake during 1970s to 2011 and to eventually estimate the water storage variations of Tibetan lakes. Furthermore, we used historical digital elevation model data and altimetry measurements to quantify the glacier mass balance and to estimate the meltwater contributions from mountain glaciers within each basins. Besides, we explored the potential links of heterogeneous changes of Tibetan lakes with key climate variables, e.g. precipitation, evaporation.

S20-O Intra-lake heterogeneity of thermal responses to climate change: A study of large Northern Hemisphere lakes. *R. Iestyn Woolway, Christopher J. Merchant*

University of Reading, United Kingdom

Lake surface water temperature (LSWT) measurements from various sources illustrate that lakes are warming in response to climate change. Most previous studies of geographical distributions of lake warming have tended to utilize data with limited spatial resolution of LSWTs, including single-point time series. Spatially resolved LSWT time-series are now available from satellite observations and some studies have investigated previously the intra-lake warming patterns in specific lakes (e.g., North American Great Lakes). However, across-lake comparisons of intra-lake warming differences have not yet been investigated at a large, across-continental scale, thus limiting our understanding of how intra-lake warming patterns differ more broadly. In this study, we analyze up to 20 years of satellite data from 19 lakes situated across the Northern Hemisphere, to investigate how LSWT changes vary across different lake surfaces. We find considerable intra-lake variability in warming trends across many lakes. The deepest areas of large lakes are characterized by a later onset of thermal stratification, a shorter stratified warming season and exhibit longer correlation timescales of LSWT anomalies. We show that deep areas of large lakes across the Northern Hemisphere as a result tend to display higher rates of warming of summer LSWT, arising from a greater temporal persistence in deep areas of the temperature anomalies associated with an earlier onset of thermal stratification. Utilization of single-point LSWT trends to represent changes in large lakes therefore suppresses important aspects of lake responses to climate change, whereas spatially resolved LSWT measurements can be exploited to provide more comprehensive understanding.

S20-O Reconstructing time series water-area-volume changes of Central Asian lakes with high intensive mult-temporal optical satellite images and altimetry data.

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Lakes in arid regions of Central Asia remain sensitive to climatic change and fluctuate with temperature and precipitation variations. Study showed that lakes in this area experience great changes in the last decades. Quantitative analysis of lake volume changes in spatio-temporal processes will improve our understanding water resource utilization in arid regions and their responses to regional climate change. However, a number of Central Asian in lakes lack lake bathmetry surveying data and in-situ observation data, the physical characteristics of these lakes usually remain unknown. About 6 lakes (Lake Issykul, Lake Sasyqkoi, Lake Saryqamysh, Bosten Lake, Urulun Lake and Shardara Reservior) in Central Asia are used to simulate their "area-level-volume" relationship by remote sensing technologies. Firstly, intensive multi-temporal lake areas during 2008-2016 are mapped with Landsat/Sentinel/ ASTER satellite images, and there are about 1~6 images every month to cover one lake. Secondly, the lake levels every 10 days during 2008-2016are derived from Jason-2. Thirdly, the robust relationship between lake areas and lake levels are developed so as to simulate a time-series lake area-level curves, and lake volume changes are retrieved from lake area-level curves. Finally, lake areas and levels beside 2008-2016 are reconstructed and their accuracies are evaluated with observation data. The result showed that high intensive muti-temporal lake areas and lake levels are useful for lake seasonal analysis and precise lake volume-area-level curves, which provide more details about volumes changes on stable and small changing lakes.

S20-O Refining the role of lakes in the global carbon cycle using satellite-based high-resolution inland water map.

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The role of lakes as hotspots in the global carbon cycle has been recognised in the recent years. However, the estimates of the CO_2 and CH_4 emissions from lakes, serving as the foundation of this understanding, were based on statistical estimate of lake number and their sizes, known to be inaccurate. We produced a new global estimates of carbon emitted in the form of CO_2 and CH_4 from lakes by replacing the statistical estimates with satellite derived, 14.25 m spatial resolution, global inland water map GLOWABO. We also produced an estimate of lake organic carbon content based on the GLOWABO, a statistical relationship between like size and volume as well as published in situ data. We found that the flux of carbon from lakes to atmosphere as CO_2 is nearly twice as high as previously estimated (0.68 Pg C yr^{-1} compared to 0.32 Pg C yr^{-1}) and the CH_4 emissions are also significantly higher (764 Tg C yr^{-1} compared to 650 Tg C yr^{-1}). As an intermediate product we also estimated the total volume of lakes to be 180 600 km^3 which is close to the latest statistical estimates (between 181 900 and 199 000 km^3). These results demonstrate that the greenhouse gas fluxes from lakes were underestimated up to now.

S20-O Remote sensing of cyanobacterial bloom in eutrophic lake.

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The occurrence and related risks from cyanobacterial blooms have increased world-wide over the past 40 years. Information on the abundance and distribution of cyanobacteria is fundamental to support risk assessment and management activities. In the present study, an approach based on Empirical Orthogonal Function (EOF) analysis was used to estimate the concentrations of chlorophyll a (Chla) and the cyanobacterial biomarker pigment phycocyanin (PC) using data from the MODerate resolution Imaging Spectroradiometer (MODIS) in Lake Chaohu (China's fifth largest freshwater lake). The approach was developed and tested using fourteen years (2000–2014) of MODIS images, which showed significant spatial and temporal variability of the PC:Chla ratio, an indicator of cyanobacterial dominance. The results had unbiased RMS uncertainties of <60% for Chla ranging between 10 and 300 μg/L, and unbiased RMS uncertainties of <65% for PC between 10 and 500 μg/L. Further analysis showed the importance of nutrient and climate conditions for this dominance. Low TN:TP ratios (<29:1) and elevated temperatures were found to influence the seasonal shift of phytoplankton community. The resultant MODIS Chla and PC products were then used for cyanobacterial risk mapping with a decision tree classification model. The resulting Water Quality Decision Matrix (WQDM) was designed to assist authorities in the identification of possible intake areas, as well as specific months when higher frequency monitoring and more intense water treatment would be required if the location of the present intake area remained the same. Remote sensing cyanobacterial risk mapping provides a new tool for reservoir and lake management programs.

S20-O Optical water types that helps monitor the water quality of inland waters from satellites.

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Under programme Copernicus European Space Agency have been launched satellites as Sentinel-3 and Sentinel-2, which provides us spectral, spatial and temporal resolution to monitor inland and coastal waters. These waters are optically complex and the water colour may vary from crystal clear to dark brown. The main influencing factors are colour dissolved organic matter, phytoplankton and amount of suspended sediments. Therefore, the remote sensing of optically complex waters is more challenging, and standards products often fail. Recently, there has been a growing interest in use of optical water type classification in ocean colour remote sensing. Classification helps to clarify relationships between different properties inside a certain class and quantify variation between the classes.

In this study, we present a new optical water type classification based on in situ measured reflectance spectra features. Classification shows, that different optical water type has different remote sensing reflectance spectrum and each water type is associated with a specific bio-optical condition. Furthermore, we estimate how well it is possible to defined different optical water types from different satellite images and from images with different atmosphere corrections. Finally, we investigate the spatial and temporal variability of the optical water types on Estonian and Latvian lakes during 2017 based on Sentinel-3 and Sentinel-2 data.

S20-O Spatio and temporal variation of suspended particulate matter using remote sensing over Lake Hongze.

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In the present study, we develop an algorithm approach to estimate the concentrations of suspended particulate matter (SPM) in Lake Hongze (the 4th largest freshwater lake in China) using MODIS/Aqua and VIIRS/NPP satellite data. Our results show: (1) inter-annual and seasonal variations of SPM concentrations in Lake Hongze are divided into two distinct periods between 2002–2011 and 2012–2015, with the transition associated to intensive dredging activities that were initiated in 2012. The dredging activities intensity and spatio-temporal distribution are described by Landsat and VIIRS Night light data. (2) SPM concentrations exhibit four typical patterns of spatial distribution which depend on local meteorological (wind speed and wind direction) and hydrological conditions (catchment rainfall and Huai River flowrate). (3) the satellite-derived SPM products obtained using MODIS/Aqua and VIIRS/NPP have a satisfactory degree of consistency. The study shows additive and synergistic effects of climate change and human activities on SPM concentrations over short and long timescales and the possibility to monitor these changes by remote sensing in shallow optically complex lakes, and VIIRS/NPP can continue the SPM observations begun by MODIS/Aqua in turbid inland waters and establish environmental datasets over long time periods to support water quality management in the future.

S20-P A cost-effective remote sensing method for boreal lake macrophyte abundance monitoring and status assessment based on an open data source.

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We utilize open data of the Finnish National Land Surveys aerial imaging project started in 2016 to apply a highly cost-effective method to monitor macrophyte cover in Finnish lakes. The mapping project provides systematic national coverage of aerial images on a 5-10 year rotation. We derive the areal cover of helophytes and floating-leaved vegetation by applying visually considered class thresholds to the Normalized Difference Vegetation Index (NDVI) calculated from 0.5 m ground resolution color-infrared (CIR) images obtained in July-early September. We control for radiometric disturbances present in the CIR image data by applying local classification thresholds, and account for shadows of near-shore trees by creating a separate shadow classification. We validated the interpretation method by ground-truth data (n=13 lakes), yielding an average classification accuracy of 83 %. We apply the thematic macrophyte cover maps together with lake bathymetric GIS data to calculate the percentage of vegetated littoral (PVL), which we use as an indicator of macrophyte vegetation status. We study the performance of PVL in ecological status assessment by collecting data from several lake types and across a disturbance gradient. Reference conditions needed for ecological status assessment are set using lake typology and predictive modelling (on-going work).

S20-P The cause of rapid lake expansion in the Tibetan Plateau: climate wetting or warming?

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Endorheic lake dynamics in the Tibetan Plateau (TP), as reflected in changes in water level and/or surface area, are sensitive indicator of regional hydrology that is closely related to both climate change and cryosphere hydrology. Since the late 1990s, most closed lakes in the interior TP expanded and deepened dramatically, in sharp contrast with lake shrinkage in the southern TP.

Although some evidence shows that glacier melting and permafrost thawing within some lakes may influence lake level changes, they cannot explain the overall lake expansion, especially for lakes without glacier supply. More and more evidence from lake water balance modeling indicated that the overall lake expansion across the interior TP may be mainly attributed to a significant increase in precipitation and associated runoff. The positive lake water budget is also consistent with regional climate changes (e.g. increase in water vapor content and air convection in the interior TP), with relevant changes in large scale atmospheric circulation to be investigated. Further studies are needed to quantify the contribution of each component to lake water budgets and the associated climate change.

S21. Removal effect on nitrogen and phosphorus by wetlands and its mechanism

S21-O Effect of operation strategy on nitrogen removal of biochar-based vertical subsurface flow constructed wetland. *Jing Li, Zhen Hu, Xinhan Chen, Jian Zhang*

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In the present study, four biochar-based vertical subsurface flow constructed wetland (System I: intermittent aeration without biochar addition; System II: intermittent aeration with biochar addition; System III: tidal flow without biochar addition; System IV: tidal flow with biochar addition), were established to investigated treatment performance and nitrogen removal mechanism. Results showed that the average DO level under tidal flow oxygen supply strategy was better than intermittent aeration. And biochar addition could optimized oxygen distribution due to excellent structure properties. Systems IV achieved the highest removal efficiencies for TOC (90.41%), NH_4^+-N (98.30%) and TN (72.22%). Microbial analyses demonstrated aerobic ammonia oxidation was the dominant NH4+-N transformation process in the present study. NH4+-N transformation rate followed the order: System I < System II < System III < System IV. Quantitative response relationship between nitrogen transformation rates and functional genes revealed that nitrogen removal was determined by various functional genes. Specifically, in the present study, TN removal was influenced primarily by nosZ in intermittent aeration systems while it was collectively governed by nirS, nirK, amoA, NSR and anammox in tidal flow systems.

S21-O Phosphorus Release Characteristics and Its Ecological Effect Under Different Hydrodynamics Disturbances in Lake Taihu. *Jianying Chao*

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The objective of this study was to investigate the impact of sediment resuspention and phosphorus release on phytoplankton growth under two kinds of wind-wave disturbance model, short-term strong wind model and long-term moderate wind model in large and shallow eutrophic Lake Taihu.

To address this objective, we (1) monitored changes in surface water composition during a field-based sediment resuspention events that were caused by a short-term strong wind course in Lake Taihu, and also conducted (2) a series of laboratory-based sediment resuspention experiments to simulate long-term moderate wind course. Our results showed that under both strong and moderate wind-wave disturbances, SS and TP in the water column increased significantly. SS and TP concentration increased sharply under short-term strong wind disturbance, and were rapidly removed from water column when the disturbance stopped, while SS and TP

concentration increased slightly and remained stable in a medium concentration. For the two kinds of wind-wave disturbance model, TDP and SRP concentrations in water column did not increase significantly, but APA and EHP concentration showed a significantly increased trend under short-term strong wind model condition, but in the short-term strong wind condition, APA and EHP peak value appears 1 day after the peak value of wind speed, and then rapidly declined.; the former also was observed increasing of Chl-*a* concentration in water column, which was not observed in short-term strong wind condition. This study demonstrated that the phosphorus released from sediments mainly existed in particulate forms. Despite short-term strong wind disturbance result in more TP release, TP will settle to the bottom of the lake rapidly after the end of wind with SS, and do nothing to promote algae growth. But due to the longer duration of long-term moderate wind model, suspended particulate phosphorus will hydrolyze to SRP by phosphatase and supply algae growth, which maybe the main route of hydrodynamic disturbances induced sediment P release contribution to phytoplankton growth.

S21-O Microbial aerobic denitrification dominates nitrogen losses from reservoir ecosystems via in situ oxygen enhanced by water-lifting and aeration technology.

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The mechanism, influence factors and nitrogen removal performances were explored through the operation of the water-lifting and aeration system in Zhoucun Reservoir. The hypolimnion anoxic layer abosolutely disappeared and the whole reservoir mixed after the water-lifting and aeration system operated about 35 days, which supplied a suitable environment for the nitrogen removal. The operating of the system enhanced the activity of water microbial metabolic and the capacity of self-purification, thus enhancing the indigenous oligotrophic aerobic denitrification bacteria to achieve nitrogen removal. The TN concentration decreased from 2.55 to 0.48mg/L with 81.18% removal rate, and the TN removal rate reached 83.51% compared with the non-operation year; the ammonia concentration decreased from 2.39mg/L to 0.15mg/L with 93.72% removal rate, and the ammonia removal rate reached 91.98% compared with the non-operation year. Meanwhile, aerobic denitrification bacteria increased from 2.56×10^3 to 1.63×10^8 cfu/mL and increased 10^4 times compared with the non-operation year. The denitrification rate had an obvious increase which were higher 10~20 times than that of the non-operation year. Furthermore, the enhanced system showed a clear inhibition of P, Fe, Mn, TOC, and S performances, which could meet the requirements of class 3, based on the Chinese Surface Water Environmental Quality Standard (GB3838-2002). The operation of the water-lifting and aeration system led the reservoir to be mixed in advance. Thus, good water quality could also be maintained after the system stopped running. The systematic investigation of the aerobic denitrification characteristics based on water-lifting and aeration technology could not only provide a theoretical foundation for the efficient nitrogen removal occurring but also provide essential technical support to improve the self-repair capacity in situ of water in Drinking water reservoir.

S21-O The Application of Pre-Dam at Estuary of Gehu Lake for the Removal of Nitrogen and Phosphorus.

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As the pre-dam of the *Taihu* lake, Gehu lake is an important area to control and prevent the pollution load reaching the *Taihu* lake from the upstream. Unfortunately, Gehu lake suffers the most serious water pollution in the *Taihu* shallow lake.

In view of the of the serious over-standardization of TN and low interception and purification capacity of the pollutants in the river basin, we carried out small or pilot tests and obtained water drop / diversion hydraulic control and strengthened purification key technology. In addition, demonstration projects were performed at the estuary of the Gehu lake. As a result, water quality of rivers entering the lake was significantly improved and the concentration of TN and TP decreased by more than 20%. Purification efficiency of the key technology changed with seasons and the removal rate of water pollutants in summer was about 5% higher than winter.

S21-O Technology and Engineering Demonstration of Reconstruction and Ecological Restoration of Shallow Lake Wetlands. *Yimin Zhang*

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Shallow lake wetland is an important part of the ecological system in the Taihu Lake basin, performing a unique ecological service function. It is not only an important link in the water cycle and the material balance of the ecosystem, but also the main source of the clear water. Gehu Lake, the second largest lake in the Taihu Lake basin, belongs to the Taoge lakes in the west of the Taihu Lake. As the pre-reservoir of the Taihu Lake, it is an important area to control and prevent the pollution load reaching the Taihu Lake from the upstream. Unfortunately, Gehu Lake is located in the northwestern Taihu Lake basin which suffers the most serious water pollution in the shallow lake.

The overall shallow lake research plans were proposed, and an integration technology ware formed of reconstruction and ecological restoration of wetlands and low pollution water purification capacity enhancement, including water pollution purification capacity enhancement technology at estuaries of lake outlet and inlet, vegetation restoration and wetland reconstruction technology in shallow water and ecosystem regulation and stability maintaining technology in Gehu Lake. The demonstration projects were carried out and reached the targets, such as improving the ecological services, pollution interception and water purification function in shallow water of wetlands. As we know, the improvement in the water quality and ecological environment in Gehu Lake can play an important role in reducing the pollution load into the Taihu Lake and improving the water quality of Zhushan Bay and the Taihu Lake. With the demonstration projects putting into effect, water quality in Gehu Lake was obviously improved and the indexes of total phosphorus, total nitrogen, ammonia nitrogen, potassium permanganate index and chlorophyll-a decreased sharply.

S21-P Study on the effect of aerated vertical flow wetland on sewage purification. *Ji Hongkang*

Nanjing Institute of Geography & Limnology, Chinese Academy of Sciences, China

Artificial aeration wetlands are widely used in the treatment of contaminated water, which has the incomparable advantages of traditional constructed wetlands. However, aeration vertical flow wetland units, as the core of Artificial aeration wetlands, play an irreplaceable role in purifying wastewater Role.

Through the model test, the change of gas-water ratio has a significant effect on the changes of COD_{Cr}, NH_3-N and TN. With the increase of gas-water ratio, the removal rate of COD_{Cr}

gradually increases. The average removal rates of NH_3-N were 31.8%, 36.9%, 40.4%, 54.0%, 60.8% and 64.1% respectively. The NH_3-N removal rate rised firstly and then declined with the increase of gas-water ratio, the average removal of NH_3-N were 40.7%, 62.5%, 79.5%, 89.7%, 76.3% and 71.9%. The TN removal rate was similar to that of NH_3-N, TN also showed the trend of first rising and then declining with the increase of gas-water ratio, and the average removal of TN were 26.2%, 27.6%, 35.8%, 48.04%, 45.8% and 43.9% respectively. The change of air-water ratio has no significant effect on the average removal rate of TP, and the removal rates of TP are 43.9%, 45.5%, 44.1%, 45.3%, 47.1% and 43.5%, respectively.

The results of model tests show that the hydraulic (pollution) load has little effect on the removal efficiency of COD_{Cr} at different gas-water ratios, and there is no significant correlation between hydraulic (pollution) load and COD_{Cr} removal rate. With aeration vertical flow wetland hydraulic (pollution) load increases, NH_3-N, TN, TP removal rate decreased gradually. There was a good linear relationship between hydraulic (pollution) load and NH_3-N, TN and TP removal rates.

S22. Reservoir limnology

S22-O Eco-environment of reservoirs in China: characteristics and research prospects.

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China is home to 97,246 reservoirs, most of which are sub-deep water reservoirs characterized by seasonal stratification and multiple interfaces in the water body. The prominent eco-environmental problems, such as eutrophication and accidental deterioration in water quality, restrict reservoir construction. Compared to natural lakes, reservoirs have specific geologic backgrounds and eco-environmental characteristics, which manifest in the following aspects: (a) the origin of the water environment and ecological system of the reservoir is different from natural lakes; (b) sediment is rich in organic matter and nutrients; (c) water eutrophication and heavy metal pollution are tightly interlocked; (d) multi-interface and seasonal stratification control the key physicochemical and biological processes; (e) the cumulative effect of the material cycle has an important influence on the water environment and ecological security; (f) artificial regulation of water level leads to the ecological degradation of the hydro-fluctuation belt; and (g) the slow response of the aquatic ecosystem to the reduction of external load. Research on the eco-environment of sub-deep water reservoirs trails that of natural lakes in China. After describing the eco-environmental characteristics of reservoirs in China, we address potential challenges and propose future research directions to develop a full understanding of the complex biogeochemical processes prevalent in reservoirs.

S22-O Vertical Variations in Trophic State Parameters and the Implications for Monitoring Design.

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Water quality in reservoirs is neither stable nor homogenous. Understanding sources of variation, both temporal and spatial, is important in informing monitoring protocols and data interpretation. This presentation focuses on vertical variation in the photic zone, to determine if

water quality in samples collected at Secchi depth differ from near-surface samples. The data set includes total nitrogen (TN), total phosphorus (TP), and chlorophyll (Chl) data from 8102 reservoir-visits made on 232 water bodies located in Missouri, U.S.A. The reservoirs span the trophic gradient, with individual Secchi readings ranging from 0.01 to 8.60 meters (median = 1.0 meter). Among the surface-Secchi comparisons, 71% of TN, 66% of TP, and 59% of Chl were within 10%. Deviations >10% for TP and Chl result in the Secchi sample being 5-times more likely to have a higher value than the surface sample. These deviations (Secchi>Surface) occur more frequently when the temperature difference between the depths exceeds 0.5°C, while TN deviations >10% tend to occur when temperature differences were >2.0°C. Differences between near-surface and Secchi samples are not consistent across the water clarity gradient. Samples collected when Secchi transparency was ≥4.0 m (n = 299) have average absolute differences for TN, TP and Chl of 59, 4, and 2.5 µg/L, respectively. In contrast, when Secchi transparency was <0.25 m (n = 241) the average absolute differences were greater (TN = 123, TP = 16, and Chl = 7.0 µg/L), even though the two samples were collected in close vertical proximity of each other. While most comparisons resulted in negligible differences, substantial disparities in water quality between near-surface and Secchi depths did occur in about 3% of comparisons.

S22-O The effects of limnological features on the taxonomic and functional diversity of fish communities in reservoirs in the Yangtze River basin.

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40 lakes were chosen to study factors structuring fish patterns and species richness in reservoirs in the Yangtze River basins. Those reservoirs were classified into three clusters according to their fish species compositions using self-organizing map. It was mainly determined by altitude, longitude, annual precipitation, the age of the reservoir, reservoir area and morphometry to classify the three clusters. The environment of reservoirs between cluster 2 and 3 are more similar than that in cluster 1. Reservoirs of cluster 1 spatially distributed in the upper reach of the Yangtze River basin with high altitude, the most contribution environmental factors were water depth, air temperature and day length for reservoirs of this cluster by MLP prediction model. Reservoirs of cluster 2 and 3 were mainly distributed in middle and lower reach of the Yangtze River basin, the significant difference between the two cluster reservoirs was the age of the reservoir, which was significant higher in reservoirs of cluster 3. The most contribution environmental factor was air temperature for cluster 2 and water depth for cluster 3. The species richness for each reservoir ranged from 1 to 95, which was significantly different among the three clusters and between each two of them. The highest value of species richness was appeared in cluster 3, while, the highest value of beta diversity were detected in cluster 1 with the lowest value of species richness. The most important role in predicting the species richness was air temperature.

S22-O Other ions than N and P, plays key roles for algal blooms to happen in Three Gorges Reservoir.

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The Three Gorges Reservoir (TGR) is the largest man-made lake of this planet. Pengxi River is the largest secondary tributary in the northern bank of TGR, and one of most algal bloomed among all of large secondary tributaries. On the other hand, Modao River, a large secondary tributary of TGR too, barely was reported with algal bloom in the same time period. Estuaries of

these two rivers are only 25 km away from each other, and similar weather and geographical conditions are shared between them. In order to understand the reasons of difference of algal bloom between these two tributaries, water samples were taken and tested in both rives in spring and summer, respectively. The results show that the maximum value of Chlorophyll-*a* (Chl-*a*) in Pengxi rive reached 60.5μg·L^{-1} in spring, and only 7.8μg·L^{-1} in summer, while 2.92μg·L^{-1} in spring and 7.48μg·L^{-1} in summer in Modao river. Most of Chl-a content was remained in thermocline. TN and TP in Pengxi were 2.305mg·L^{-1} and 0.053mg·L^{-1}in spring, and 1.673mg·L^{-1} and 0.097mg·L^{-1} in summer, respectiverly; while in Modao River were 1.875mg·L^{-1} and 0.075mg·L^{-1} in spring, and 1.79mg·L^{-1} and 0.054mg·L^{-1} in summer, respectively. Nutrients concentrations showed no significant co-relationship with Chl-*a*. On the other hand, conductivity showed totally difference between these two rivers: in Modao River in spring-the algal bloom season in TGR, the conductivity in its upstream, where the highest Chl-*a* happened in the whole river, was only 75% of that of the main stream of the Yangtze River; while in the upstream of Pengxi, where the highest Chl-*a* happened in the whole river, the conductivity was 150% of that in the main stream. The study shows that other than N and P, other ions in the Pengxi River played an important role in bursting "bloom".

Our study suggests that re-establishment of submerged macrophytes plays a key role in overcoming the negative resilience of the turbid states. Transplanting submerged macrophytes combining with fish removal and water level reduction or phytoplankton precipitation may rebuild the clear water states within a few months in tropical and subtropical Chinese lakes.

S22-O Impacts of extreme precipitation events on ecosystem of Lake Qiandao – a model approach.

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Lake Qiandao is the largest reservoir with an area of 580 km^2, mean water depth of 30.4 m and maximum depth of 100 m. The lake with huge water capacity of 178.4×10^8 m^3 is providing drinking water for half million local people and will supply drinking water for nearly 8 million at Hangzhou City. The main tributary is Xinanjiang which is originally from Anhui Province at the northwest of lake. Xinanjiang is contributing 59.4% of the Total Annual TP (TATP) external loading and 64.9% of the Total Annual TN (TATN) external loading to the lake. Rainstorm ($\geqslant$ 50 mm/day) is characterized of significant riverine nutrient inputs at a short-time scale, leading to quick water quality degradation and remarkable water level increase. There has been 5.5 rainstorms per year based on statistical analysis on meteorological data during 2006 - 2016, accounting for 23.8% of the total annual precipitation. The rainstorms have caused 30.8% of the total lake inflows and have carried 14.9% of TATP and 15.4% of TATN through Xinanjiang to the lake. In order to provide insight into rainstorm impacts on ecosystem, a three-dimensional hydrodynamic-ecosystem model (ELCOM-CAEDYM) has been applied to Lake Qiandao to simulate huge inflow-induced currents, tracer dispersion, water quality status and significant water level fluctuation effects on ecosystem. The results show that the time scale of tracer diffusion from Xinanjiang to the dam is about 50 days with normal inflow volume of 150 - 200 m^3/s, about 26 days with peak rainstorm-induced inflow volume of 955 m^3/s and about 14 days with peak extreme rainstorm-induced inflow volume of 2493 m^3/s. The quick inputs of huge water and nutrients can greatly affect the water quality and temperature profile in the lake, requiring long time to restore to the previous status.

S22-O The summer-centric summary: should we open the window?

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Reservoir studies have largely focused on the conventional sampling season (May through August). By monitoring during the warmest months, we may be missing the bigger picture. A long-running citizen science program in Missouri, USA monitors reservoirs across an extended period that includes a month before and after summer (April through September). Most reservoirs are not fully stratified in April and destratification begins in September. This 25-year dataset (230 reservoir sites) allows us to ask: do reservoir characteristics from the extended period differ from our conventional sampling window? We compared temperature, Secchi, total phosphorus (TP), total nitrogen (TN), chlorophyll, and non-volatile suspended solids (NVSS) across the entire dataset (April through September), with values from April, summer (May through August), and September. Overall, site-specific summer means were similar to values calculated for the extended period. Trophic state assessments remained the same in 94% of observations. Temperature in April averaged 6.7 C lower than the entire dataset. Secchi means were similar across all periods (1.05 – 1.11 meters) and there was little variation in TP (34 – 39 µg/L). The TN concentrations were more variable, with highest averages in April, likely from spring inflow, and lowest in September (749 and 588 µg/L, respectively). The NVSS showed a similar pattern as TN (4.4 and 2.9 mg/L, respectively). Conversely, chlorophyll was lowest in April and highest in September (10.2 and 18.1 µg/L, respectively), which may result from improved light and warmer temperature. Conventional sampling during summer is broadly similar to estimates from April through September in these reservoirs but does not capture seasonality. Inflows are likely important in April and internal loading in September. Other Missouri studies show chlorophyll peaks during fall mixis. Monitoring during summer provides an estimate of trophic state but misses seasonality.

S22-O The impact of rainfall patterns on phytoplankton dynamics of a subtropical karst reservoir, southwest china.

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Currently, the effects of climate change and human activity on aquatic ecosystems are receiving much attention. However, the lack of research on karstic lakes means that knowledge remains limited about their potential value. Rainfall is assumed to be the important climate factor with temperature together regulating phytoplankton composition and succession. Thus, here we explore how rainfall patterns reveal phytoplankton dynamics in a karst plateau reservoir (the Aha Reservoir) in Southwest China to develop an effective management strategy. Although due to the human interference and regional characteristic, the correlation of rainfall and nutrients were not so clear, the results also confirmed that both rainfall (biomass: n=48, r=0.806) and temperature (biomass: n=48, r=0.701) triggered phytoplankton community succession. Initially, cyanobacteria rapidly increasing (peak biomass: 245.68 µg/L), soon this advantage was lost when thermal stratification was disturbed by long periods of precipitation. Diatoms remained the dominant phytoplankton group in the Aha Reservoir (almost relative biomass > 50%). Changes in rainfall and temperature caused variation in phytoplankton biomass and diversity. Because the unique of karst reservoirs, we should continuously the monitoring work to elucidating the dynamic characteristics of phytoplankton community structure and forming a guide oriented to future management.

S22-O Responses of phytoplankton communities to the regulation of the Three Gorges Reservoir.

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Three Gorges Reservoir (TGR) is the biggest deep river-type reservoir in the world. The aquatic ecosystem of the Yangtze River have been changed markedly since the Three Gorges Dam's impoundment. In order to know the characteristics of phytoplankton communities in the TGR, sampling campaign was conducted monthly from 2003 to now. Responses of phytoplankton communities to the regulation of the TGR was demonstrated in this paper. After the first impoundment in June, 2003, biomass and species of phytoplankton changed rapidly; biomass increase significantly, some dominant species appeared, Diatoms are no longer the largest group. Impoundment could changed the communities significantly. During the 135 m – 175 m regulation period, phytoplankton in the low water level stage was significant differed from the high water level stage. dominant species, cell density, biomass and biodiversity index in the low water level were higher. Along the tributary of the TGR, the obvious spatial distribution characteristics was obtained, phytoplankton in the backwater area (from midstream to downstream) could be divided into four groups, which related to the impoundment stage, high water level stage, water level decreasing stage and low water level stage respectively. Water blooms could be observed in the tributary in spring and summer. This characteristics was related to the hydrodynamics. phytoplankton in the backwater area differed from the non backwater area (upstream). It could be concluded that regulation of the TGR could changed phytoplankton communities significantly through the changing of hydrodynamics. Hydrodynamics was the key determining factor for the phytoplankton, which implied water blooms in tributaries of TGR could be treated efficiently by the optimal man-made water flow.

S22-O Study on the effects of temperature, dissolved oxygen and pH on phosphorus release at the sediment-water interface in deep reservoirs using high-resolution sampling techniques.

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Phosphorus (P) is widely regarded as the primary factor responsible for lake eutrophication, and P release from sediments was proven to be a major source of P to the water column. Up to now, the processes and the mechanisms of P release affected by the temperature, dissolved oxygen (DO) and pH at the sediment-water interface (SWI) were not well illuminated, due to lacking *in-situ*, high resolution monitoring techniques. In this study, simulating experiments were conducted using sediment cores collected from Hongfeng Reservoir, one of the biggest deep reservoirs, Southwestern China. The Zr-oxide diffusive gradients in thin films (DGT) technique in combination with microelectrode technique was employed to determine the *in-situ*, high resolution concentration distributions of dissolved reactive P (DRP) at the SWI under varied temperature, dissolved oxygen and pH conditions. The results showed that the concentrations of DRP in the sediments increased rapidly as the simulating temperature increased, reflecting a rapid P release from sediments. Under the high temperature condition, the NaOH-P concentrations showed the greatest decrease (accounting for 79.3% of total decrease) in the sediments, suggesting that the increase of DRP at the SWI was mainly due to the transformation of NaOH-P. Under different DO conditions, concentrations of DRP in the sediments significantly increased as the sediments were cultured under low oxygen (DO<1.0 mg/L). Mean concentrations of total P in the sediments decreased approximately 25.2% (Site outlet) and 16.5% (Site south central), respectively. At the outlet site, the largest component of P decrease in the sediments was for NaOH–P. A decline of 384.7 mg/kg on average accounted for 85.3% of the total P decrease. At the south central site, two large components of P decrease in the sediments were for Residual–P and NaOH–P. A decline of 281.4 mg/kg on average accounted for 89.5% of the total P decrease. Thus, the increase in DRP in pore waters and overlying waters thus was mainly from the transformation or desorption of

NaOH-P and/or Residual–P under high temperature and low oxygen conditions. Under both high (pH9.5) and low (pH5.5) pH conditions, sediment shows high level of P release potential. Our results provide new information for illuminating P biogeochemical cycling processes at the SWI in deep reservoirs. More detailed knowledge of the *in situ* microscale changes (e.g., O_2, H_2S, and Fe) of the SWI is required to understand the mechanisms of the P migration in freshwater sediments.

S22-O Stratification dynamics in a reservoir under different wind conditions.

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Stratification dynamics in reservoirs have a great impact on ecosystem functioning and biogeochemical cycling, and can be strongly influenced by climate change. When evaluating the response of thermal dynamics to climate change, most studies focused on the effect of global warming and little attention has been paid to the influence of other meteorological factors, e.g. changing wind speed. In this study, a well-established one-dimensional hydrodynamic model (GLM) was used to investigate the response of stratification dynamics in Rappbode Reservoir (eastern Germany) to different wind conditions, in particular to episodic strong wind events. In years with increased wind speed, stratification duration and intensity were reduced. Episodic wind forcing by strong wind events are important determinants of thermal structure and can induce persisting shifts in the thermal structure that remained until the next overturn over the season. The results showed that reductions in stratification intensity were particularly distinct when the strong wind occurred in early summer. Strong wind events outside of this sensitive time window did not exert an important impact on the thermal dynamics of the reservoir. Our research confirms the decisive impact of wind speed on stratification of lakes and reservoirs. It effectively illustrates the sensitive time window of thermal dynamics to episodic wind events.

S22-O Spatio-temporal variations of the stable H-O isotopes and characterization of mixing processes between the mainstream and tributary of the Three Gorges Reservoir.

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Understanding the runoff characteristics and interaction processes between the mainstream and its tributaries is essential issue in watershed and water management. In this research, hydrogen (δD) and oxygen ($\delta^{18}O$) isotopes technique was used in the mainstream and Zhuyi Bay (ZYB) of the Three Gorges Reservoir (TGR) during the wet and dry seasons in 2015. It revealed that (1) precipitation was the main source of stream flow compared the TGR water line with meteoric water line of the Yangtse River basin; (2) the δD and $\delta^{18}O$ values exhibited a 'toward lighter-heavier' trend along mainstream due to the continuous evaporation effect in the runoff direction, and the fluctuations reflected incoming water from the nearest tributaries. The general trend of d-excess increased with increasing distance from the Three Gorges Dam, which indicated that kinetic fractionation was an important process affecting the isotopic composition. The enrichment effect of isotopes was found in the downstream of TGR; (3) water mass from the TGR mainstream flowed backward to the confluence zone of ZYB via the middle and bottom layers in

the dry season, whereas in the wet season, water reversed through the upper-middle layers due to thermal density flows. This study described and demonstrated that the water cycle of TGR was driven by natural environmental variability and operation system, which will provide valuable information for the water resource management and the algal blooms controlling in the future.

S22-O Diurnal variation and influencing factors of carbon dioxide and methane emissions at water-air interface of Caotang River, Three Gorges Reservoir in the initial impoundment period.

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With the LGR-floating chamber method, a 24-hour continuous monitoring was carried out in the initial impoundment period of Three Gorges Reservoir, in order to understand the greenhouse gases fluxes (carbon dioxide and methane) across the water-air interface of Caotang River which is the primary tributary of the reservoir. The results indicated that the fluxes of carbon dioxide and methane across the water-air interface appeared an obvious characteristic of diurnal variation. The fluxes of carbon dioxide ranged from -81.642 to 180.991 mg/(m^2·h), and the average fluxes of carbon dioxide were 17.346 mg/(m^2·h). As a result, the overall carbon dioxide showed "absorb by day and emit at night". Methane was emitted all day with the average fluxes of methane 0.064 mg/(m^2·h) showed "strong at day and weak at night". The fluxes of carbon dioxide and methane were positively correlated with wind speed while negatively correlated with water temperature of surface layer, dissolve oxygen and chlorophyll-a. It could be explained the most important factors that influence emissions at water-air interface were phytoplankton photosynthesis and bacterial metabolism process in the surface water. The changes in greenhouse gases emissions at water-air interface were also relevant to special environment (density current and thermal stratification) due to the interaction between main current and tributaries. The hydrodynamic factors were the key factors that affect carbon cycle and the greenhouse gases fluxes across the water-air interface in backwaters of tributaries, which would be worth researching.

S22-P Physiological responses of *Synechocystis* sp. PCC6803 to H_2O_2 stress: the revival mechanism and its implication.

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Hydrogen peroxide (H_2O_2) was thought to inhibit cyanobacterial growth efficiently, but it was amazing that H_2O_2 application in cyanobacterial bloom control was always inefficient. This study was conducted to screen responses of *Synechocystis* sp. PCC6803 to H_2O_2 stress and find the reason why using of H_2O_2 in cyanobacterial bloom control was inefficient. Intra-cellular reactive oxygen species (ROS), activities of antioxidant enzymes, rates of oxygen evolution and uptake, chlorophyll fluorescence activities and D1 protein were measured under different concentrations of H_2O_2. The results showed that H_2O_2 treatment enhanced the accumulation of ROS in cells. Subsequently, it efficiently attenuated Q_B-reducing centers and inhibited the activity of photosystem II (PSII). After H_2O_2 was removed, the revival process was observed. Antioxidant

enzymes played important roles to degrade ROS. The recovery process of PSII was divided into two phases, the first phase was independent of D1 protein and the second was dependent on D1 protein. Cyclic electron flow (CEF) was also indispensable to the recovery and it could be stimulated by H_2O_2. Based on data of oxygen uptake and post-illumination kinetics, CEF stimulation was originated from NDH-mediated respiration. It was concluded that cyanobacteria could be easily impaired by H_2O_2, but the resistance to oxidative stress, such as antioxidant enzymes and CEF, guarantee the capacity of recovery. It is the reason why H_2O_2 application in cyanobacterial bloom control was always inefficient. It also implied that H_2O_2 application should be optimized and keeping a long-term effective concentration may be useful for cyanobacterial bloom control.

S24. Scales and aggregation in cross-lake analysis

S24-O Phosphorus-precipitation and Chlorophyll a-phosphorus relationships of lakes and reservoirs mediated by soil iron at the regional scale.

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Phosphorus is a critical element determining trophic status and Chlorophyll *a* (Chl *a*) level in lakes, and its budget is substantially influenced by flushing rate associated with precipitation. Precipitation directly promotes phosphorus loading to lakes through runoff and soil erosion transferring phosphorus from catchment to lakes and reservoirs. As soil phosphorus is tightly bound with soil iron, the effect of precipitation on total phosphorus (TP) concentration in lakes may depend on soil iron, which has a regional pattern connected to climate conditions and geology. Hierarchical linear models for lakes and reservoirs across a large geographic area in China show that latitudinal patterns in TP-precipitation and Chl *a*-TP relationships are explained in part by soil iron. Soil iron functions as a regional variable that mediates the influence of precipitation on TP concentration for both lakes and reservoirs, and indirectly drives the latitudinal variation in Chl *a*-TP relationships for reservoirs. The increase in extreme precipitation events anticipated under future climate conditions may substantially mitigate eutrophication in tropical and subtropical reservoirs, but may worsen conditions in temperate lakes.

S24-O The end of the line: What hypereutrophic soda-lakes can tells about virus-bacteria-chlorophyll a relationships.

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Ratios between viruses, bacteria and chlorophyll a reflect structure and energy flows within microbial food-webs and are thought to change systematically with system productivity. The drivers of these changes, however, have not yet been unanimously resolved. In this study, we focused on the extreme end of the productivity spectrum and assessed microbial dynamics in hypereutrophic African soda-lakes to provide mechanistic explanations for shifts in microbial biomass ratios.

In a meta-analysis of marine, freshwater and African soda-lake systems, we confirmed that

both virus-bacteria and bacteria-cholorohpyll a ratios decrease with trophic status. High-frequency sampling of two soda-lakes revealed several drivers of ratio changes. A structural equation model suggested that particulate matter (PM) simultaneously influenced densities of viruses negatively and bacteria positively, turning PM in a driver of virus-bacteria ratios. Further, bacteria densities were strongly bottom-up controlled. Lower bacteria-chlorophyll *a* ratios may therefore reflect a weaker coupling between algal densities and DOC excretion rates. In support of this hypothesis, the epilimnon of soda-lakes was much deeper than their euphotic zone. Therefore, higher algal densities increase light limitation but hardly affect primary production and carbon excretion rates. However, we also found that statistical effects and changes in variability can alter ratios systematically, highlighting that observed impacts of eutrophication may best be explained by multiple, possibly interacting factors.

S24-O Global Body Size Distribution and Variability of Cladocera.

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We examined the distribution of body size among freshwater Cladocera across different taxonomic levels, climatic regions, biogeographical realms and habitats. Miniaturization seems to be the key strategy in determining overall success of most species of freshwater Cladocera. We used extensive literature data to demonstrate the global distribution of body size in freshwater Cladocera. Hierarchical models were used to assess the effects of grouping variables on the variability of body sizes. Overall distribution of cladoceran body size is right skewed (overall skewness=0.63) and the similar distribution was observed across climatic regions and biogeographical realms. However, differences were observed between pelagic and littoral species. Larger sized taxa were observed to be more distributed in colder climatic regions and biogeographical realms, pelagic zones and habitats with usually low predation or fluctuating predation pressure. The hierarchical models showed that taxonomic affiliation (Genus and Family levels) contributes more to the variability of body sizes compared to geographical distribution (climatic and biogeographical) and choice of habitat (habitat specificity and water zone).Larger body size in colder regions, pelagic zones and certain habitats with low vertebrate predation risks is an adaptation to both abiotic and biotic factors in their ecosystems. The absence of vertebrate predators allows large species to have a competitive edge in low-nutrient environments. However, generally small body size is favored in most freshwater environments. This adaptation serves as a means to reduce predation risk, promote co-existence within species, and metabolically adapt to a wider range of temperatures. Body size variability in Cladocera is highly influenced by taxonomic affiliations rather than environmental factors suggesting that it is a conserved trait. Trophic position and preferred habitat also influence this trait substantially. These explanatory variables are also connected to a species taxonomic affiliation. Thus body size is a trait important to the survival and continuing evolution of Cladocera.

S24-O Hierarchical Modelling and Spatiotemporal Interpolation of Cross-Sectional Lake Data for Finnish Lake Management.

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Region and lake specific management in Finland is traditionally based on hydrological and hydro-biological In-Situ monitoring. On top of that new technologies and public participation provide a lot of new data from satellites, automatic sensors and from volunteer citizens. Data are harmonized, spatiotemporally interpolated using state-space modeling and Kalman Filtering and pooled to less monitored lakes using hierarchical modelling strategies. Sparse species community data are modelled accordingly by sharing information among species and to account species associations in explaining and predicting species occurrences. The impacts of climate change and socio-economic drivers are modeled and effective policy and management options are identified in a public participation process using adaptive monitoring and management strategies.

S24-O Temporal Changes in the Relationship between Microcystin Toxin Concentration and Cyanobacterial Concentration in Western Lake Erie.

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The increasing frequency of harmful algal bloom (HAB) in Western Lake Erie (WLE) Basin is linked to the increased risk of human exposure of the cyanobacterial toxin microcystins. The toxin production is a complex process linked to not only cyanobacterial volume but also to other factors that are not well understood. Using data from NOAA-GLERL's annual HAB monitoring, we examine the dynamic change of the functional relationship between microcystin concentrations (MC) and cyanobacterial volume in WLE, from which to explore the likely factors related to the toxin production. Through exploratory data analysis, we find that the MC concentration is relatively stable and low when cyano volume is below a threshold, after which MC concentration, as well as its variability, increase as cyano volume increases. This pattern can be adequately modeled with a hockey-stick model, a piecewise linear function with two joint line segments intercept at the threshold. The line segment to the left of the threshold (the first line segment) has a slope near 0 and the line to the right of the threshold (the second line segment) has a positive slope. The threshold is a measure of the propensity of toxin production and the slope of the second line segment is a measure of the rate of toxin production. Exploring the dynamic changes of these two parameters allows us to develop hypotheses of factors associated with MC production, which may include nutrient loading, water temperature, and total primary productivity. This presentation discusses preliminary findings based on annual monitoring data from 2009 to 2016.

S24-O Simpson's paradox -- implications for cross-scale inference in lake eutrophication management.

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Vollenweider's revolutionary work in assessing the cause of lake eutrophication not only implicated phosphorous as the main culprit of algal growth but also validated the approach of data synthesis by grouping data from multiple lakes. The successful recovery of Lake Erie in the 1980s further solidified the general approach established by Vollenweider. Over the decades since Vollenweider's report to OECD, limnologists routinely use sample averages from numerous individual lakes to examine patterns across lakes. The assumption behind the use of cross-lake data is often that responses within and across lakes are identical. This assumption, however, requires verification. Using two large cross-lake data sets, we illustrate that this assumption is usually unjustified. Through comparisons of a simple and commonly used empirical model of the effect of nutrients on algal growth, we discuss the cognitive importance of distinguishing factors affecting lake eutrophication operating at different spatial and temporal scales and presenting an

analytic tool for properly structure the data analysis when data from multiple lakes are employed.

S24-P The dependence of biomass prediction by chlorophyll a concentration on phytoplankton community composition and trophic status.

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Estimating biomass of a phytoplankton community is one of major concerns in ecological monitoring. In general, phytoplankton biomass is calculated by counting abundance of each species and its cell volume, or directly indicated by pigment concentration (e.g. chlorophyll *a*). As counting abundance is time-consuming and also requires a good taxonomic experience, and chlorophyll a (Chl*a*) is commonly used as an alternative biomass indicator. However, cellular content of chlorophyll *a* is specific dependence on growth conditions such as nutrient level, temperature and light intensity in the waterbody. That is to say, the relationship between Chl*a* and phytoplankton biomass can change widely with species and environmental condition, which are presented by phytoplankton community composition and trophic status. To understand the dependence of biomass prediction by chlorophyll *a* concentration, we intensively sampled in tropical reservoirs, and examined the effects of cell size, trophic state index and dominant taxonomic groups. We applied a hierarchical model to predict phytoplankton biomass by chlorophyll *a* concentration cross seven size classes, four trophic classes and five taxonomic groups. Slope of biomass-Chl*a* regression significantly increases with average cell volume of the phytoplankton communities, and the slope increased with trophic state index (TSI). In fact, change in average cell volume of the phytoplankton and trophic state index are showed shift in taxonomic composition of phytoplankton. For example, Chl*a* content of Bacillariophyta is higher than that of Cyanophyta and mixotrophy algae (including Dinophyta, Cryptophyta, Cryptophyta and Euglenophyta). Our hierarchical model provides a way to estimate phytoplankton biomass by chlorophyll *a* concentration of a water sample with its trophic status and taxonomic composition.

S25. Sediment: internal process and pollution remediation

S25-O The effects of water level control by sluice on the regime shifts and the nutrient cycling in Lake Chaohu, China.

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In the last several decades, the rapidly increasing demand for flood control and secured water availability has stimulated water level control (WLC) by nearly one million dam and sluice constructions globally, of which 5% are located along the Yangtze River in China. Unfortunately, the potential negative effects of WLC on lakes at the ecosystem level have not yet received the scientific and societal attention. Here, we focus on a large shallow lake (Lake Chaohu) located in one of the most densely populated areas in China, the lower Yangtze River floodplain, which has undergone both WLC and increasing nutrient loading over the last several decades. A novel methodology that combines both consistent evidence from field observations and paleolimnological records with a well-established process-based ecosystem model was developed to study the effects of WLC by sluice on the nutrient cycling and regime shifts in Lake Chaohu. We identified the occurrence of two regime shifts: one in 1963, characterized by the abrupt disappearance of submerged vegetation, and another around 1980, with strong algal blooms being observed thereafter. We further disentangled the roles of WLC and nutrient loading, showing that the 1963 shift was predominantly triggered by WLC after the sluice operation in the December of 1962, whereas the shift ca. 1980 was attributed to aggravated nutrient loading. The model scenarios shows that, compared to the dynamics driven by nutrient loading alone, WLC resulted in

earlier disappearance of submerged vegetation and emergence of algal blooms by approximately 26 years and 10 years, respectively, due to the increase of the nutrient accumulation and the reduce of the critical nutrient threshold loading. Our study reveals the significant role of WLC by sluice in driving shallow lake ecosystem dynamics, and it highlights the urgency of using multi-objective management criteria that includes ecological sustainability perspectives when implementing hydrological regulation for aquatic ecosystems around the globe.

S25-O Biogeochemistry of dissolved organic nitrogen in Plateau lake.

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The objective of this study were to (1) using multiple combined analytical techniques and Fourier transform ion cyclotron resonance mass spectrometry to characterize the chemical composition and molecular structure of dissolved organic nitrogen in Plateau lake, (2) explore the difference of structure, composition and bioavailability of dissolved organic nitrogen in overlying water and sediment, (3) discuss the Biogeochemical cycle of dissolved organic nitrogen in Plateau lake based on the Interface process and mechanism as well as response to basin evolution.

S25-O Effect of internal load from crab aquaculture on water quality in Yangcheng Lake.

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Pen aquaculture is the main form of aquaculture and has become an important source of eutrophication in China, especially in the shallow lakes locate along Yangtze River. Yangcheng Lake, the third largest freshwater lake in the Taihu Lake Plain, and is well known for the production of high-quality Chinese mitten crabs. Previous rapid expansion of pen culture had caused deterioration of lake water quality, and local government started restriction of the pen culture area. The internal pollutant load from crab aquaculture including residual feed of crab, the organic matter in sediment and crab excretion, has significant effect on water quality. The internal pollutant load in terms of nitrogen and phosphorus produced during per farming cycle in a unit crab aquafarm (6667m^2 aquaculture area) was investigated using the sediment release test and crab feed metabolism test. The results of sediment release test indicated that nitrogen was released as NO_3^--N at the rate of 3.17 mg·(m^2·d) $^{-1}$; and dissolved phosphorus was released at the rate of 0.12 mg·(m^2·d)$^{-1}$. Feed metabolism test results showed that that on the basis of crab weight (kg), the specific rates of nitrogen and phosphorus released were 35.22 mg·(kg·d)$^{-1}$ and 3.40 mg·(kg·d)$^{-1}$, respectively. The nitrogen excreted into water was mainly from the liquid excrement in the form of NH_4^+-N; while the majority of released phosphorus was from solid suspended with a non-dissolved state. During a crab breeding farming cycle, the estimated maximum nitrogen and phosphorus released into water were 68.29 mg·(m^2·d)$^{-1}$ and 7.05 mg·(m^2·d)$^{-1}$, respectively. The nitrogen and phosphorus pollutants were mainly attributed to the residual feed, which accounted for 79.90% and 83.83%. In addition, the pollutants from crab excretion contributed about 15.47% and 14.47% to the N and P budget, and the release of N and P from sediment contributed 4.63% and 1.70%, respectively.

S25-O Inflowing riverine DOM reshaped lacustrine DOM quantity and quality mediated by microbes in Chaohu Lake.

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Understanding the quantity and quality of dissolved organic matter (DOM) is critical for explaining the effects of exports of terrigenous DOM on its biogeochemical cyclesin lacustrine ecosystem. In the present study, we calculated the inflowing riverine DOC flux into Chaohu Lake, analyzed the microbial community composition in sediment by high-throughput sequencing technology, and evaluatedhow lacustrine water DOM influence spatial patterns of water-extracted sediment organic matter (WSOM), and probed the transformation of WSOM under the media of microbes. We used absorption and excitation-emission-matrix (EEM) fluorescence spectroscopy to characterize the optical properties of riparian WSOM andlacustrine water DOM from Chaohu Lake, China. Our results showed that there was 5.62×10^6 g/yr riverine DOC flux exported into Chaohu Lake. Fluorescenceregional integration (FRI) technique revealed DOM composition would marked change after riverine DOM exported into Chaohu Lake, and BIX and HIX values of WSOM were notable different that from inflowing riverine DOM. In addition, humic acid-like in lacustrine waterwas significantly correlated to tyrosine-like and tryptophan-like in sediment ($P< 0.05$ or $P< 0.01$). Furthermore, redundancy analysis showed that the relative abundance of *Proteobacteria*, *Firmicutes, Chloroflexi, Acidobacteria and Actinobacteria* were correlated with the ratio of tyrosine-like and tryptophan-like ($P< 0.05$). We concluded that inflowing riverine DOMcould reshapelacustrine water DOM compositions, and precipitated in sediment and transformed mediated by microbes.

S25-O The geochemical process of S, Fe and P in sediments under the stresses of high salinity and heavy pollution.

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The geochemical process of S, Fe and P in sediments relates water quality. In present study, the optimized cold diffusion method, the SMT method and the hydrochloric acid extraction method were applied to determine the different reductive inorganic sulfur (RIS), inorganic phosphorus, and reactive iron in sediments, respectively. Surface sediments were collected from the Jiaolai River (JL, high salinity), the Jiehe River (JH, heavy pollution) and their offshore areas in the Bohai Sea. Results indicated that average concentrations of total P, RIS and reactive iron in heavy polluted river (JH) were higher than those in high salinity river (JL) and their offshore sediments. The NaOH-P dominated the fractions in the JH, while the HCl-P was the primary P fraction in the JL and offshore sediments. The RIS was dominated by the pyrite sulfur in study areas. The Fe(II) was the main reactive iron in sediments. Active organic matters could enhance the organic P to inorganic P under the heavy pollution stress. In high salinity river and offshore sediments, sulfate reduction and Fe(Ⅲ) reduction resulted in the accumulations of sulfide and Fe(Ⅱ). In the process, Fe-P released with Fe(Ⅲ) decrease, then the produced reduced Fe (II)

reacted with soluble H2S to produce the acid-volatile sulfur and pyrite sulfur.

S25-O Hypoxia and acidification induced sediment phosphorus release and downriver export from a subtropical river reservoir.

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Hypoxia is commonly developing during the summer stratified period in freshwater eutrophic reservoirs. While the causes of eutrophication and accompanied hypoxia are well studied, much less is known about their effects on nutrient biogeochemistry. Here we examined the effects of hypoxia (DO<2 mg L^{-1}) and acidification (reduced pH) on sediment phosphorus (P) mobilization and fluxes across the sediment-water interface in subtropical reservoirs, SE China. Lateritic red soil is widespread in the watershed and is rich in Fe_2O_3/MnO_2. As a result, surface sediment P was dominated by Fe/Al-P which accounted for more than 50% of TP. Sediment cores (11 cm in diameter, 50 cm in length) were collected in summer (August 2016) in the lower reservoir with a depth of 60 m. High-resolution diffusive gradients in thin films (DGT) analysis showed clear large variations in profile mobile P (SRP and DGT-labile P) in sediments. There was a large positive SRP diffusion flux across the sediment-water interface under hypoxic condition in hypolimnion. Results from the microcosm experiments of slurry sediments at five pH gradients suggested that SRP and Mn were released from sediment into overlying water when the pH value decreased. Increased eutrophication might lead to oxygen deficiency and acidification and subsequently promote release of phosphate from anoxic sediments. Current results implied that global proliferation of hypoxia and acidification in river reservoirs will substantially alter nutrient cycling and downriver export and thus deteriorate water quality and eutrophication in coast waters.

S25-O Organic phosphorus in lake environment.

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Phosphorus (P), being a major growth limiting nutrient in the biosphere, usually plays a key role in governing the biological productivity of aquatic ecosystems. Eutrophication due to elevated P inputs to the aquatic environment therefore increases the risk of algae blooms and impact on water quality. Organic phosphorus (OP) is recently conceived as a potential pool for bioavailable P, spurring much research regarding the size of OP pools and its specific compounds using 31P nuclear magnetic resonance (NMR) spectroscopy in surface sediments/soils. The amount of OP and its distribution among different pools in lake sediments depends on biotic and abiotic processes driving the OP fractionation. So far there have been no publications describing the relationship of the vertical distribution of OP pools in sediments with the water depth, lake area, and the salinity, as influenced by changes in the environment and climate. This work was to (1) investigate the characteristics of OP fractionations in sediments, (2) interpret the geochemical information derived from the correlations between OP pools and the OM composition and physiochemical characteristics, (3) assess biotic and abiotic factors that govern the distribution of OP pools in aquatic environment, (4) discuss the responses of OP pools in sediment profile to the historical evolution of Lake Hulun on the basis of quantificational reconstruction of lake level,

area and salinity over the past 4000 years. Our work provides a better understanding of responses OP fractionation to environmental conditions and lake evolution.

S25-O Sieved Transport and Re-distribution of (Bioavailable) Phosphorus from Watershed with Complex River Networks to Lake.

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We developed an innovative approach to reveal phosphorus (P) spatial patterns and its redistribution in large and complex river networks in the Lake Taihu basin by establishing the relations between sediment P spatial distribution and P sorption behaviour on particles with differences in grain size distribution, sorted by hydrodynamics. Sediment P fractionation composition changed greatly across the basin, where 69% acid-soluble fractions (HCl-P) occurred in upstream rivers, while 70% fractions associated with reducible metal hydroxides (BD-P) and amorphous hydroxides (NaOH25-P) occurred in downstream rivers. Fine particles enriched in BD-P and NaOH25-P fractions tended to sorb liberated P during the re-suspension process and fine particles were easily transported downstream and the lake, forming “sieves” of P transport in the river networks. This will lead to a great potential for sediment P release when environmental anoxia was developed in the sediments, or high pH occurred in sediment surface during intensive algal blooms in the shallow lakes. Reduction of external P of point sources from urbanized areas is an important requirement at a basin scale; however, long-term efforts are needed to restore aquatic macrophytes in the lake, which would decrease P recycling rates at the water-sediment interface.

S25-O ^{13}C dating: principles and applications. *Eric Lichtfouse*

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Despite almost a century of research on natural organic matter, we still do not know much about the sources, behavior and fate of organic substances and pollutants in complex media such as soils, sediments, waters, air and living organisms. This is due to the extreme complexity of natural organic matter, the major part being molecularly unknown. This is also due to the lack of analytical methods to assess the structure, the transformation and the transfer of organic compounds in complex media. Here I present a new method, named 13C-dating, which allows to measure to dynamics of organic substances in complex media (1). This method was designed following the unexpected discovery of several temporal pools of different age of the same compound, a leaf n-alkane, in a same soil sample. For instance, the C31 alkane in the sand fraction is about 32 years younger that the same compound encapsulated into soil humin. This discovery means that a single compound can have a very different behavior depending on its location in the sample. The novel method thus opens a new field of research to study organic compounds and pollutants in complex media.

S25-O Different Influences of bacterial communities on Fe (III) reduction and phosphorus availability in sediments of the cyanobacteria- and macrophyte-dominated zones.

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Little is known about the effects of the bacterial community on the iron and phosphorus cycles in sediments across different primary producer-dominated ecosystems in different seasons. Lake Taihu provides a suitable study area by having cyanobacteria- and macrophyte-dominated zones co-occurring in one lake. The abundance and composition of bacterial community was investigated using qPCR and 16S *r*RNA gene amplicon high throughput sequencing, respectively. Compared with sediments in the cyanobacteria-dominated zone, sediments in the macrophyte-dominated zone had higher TP, TOC and TN contents but lower DO and Eh values. The soluble reactive P (SRP), soluble Fe, and their molar ratio (Fe/P) were lower in the cyanobacteria-dominated sediment than those in the macrophyte-dominated sediment. Consistent with this was the significantly lower abundance of total and typical Fe redox transforming bacteria in the cyanobacteria-dominated sediment than those in the macrophyte-dominated sediment. Correlation analyses also revealed positive influence of abundances of total bacteria and typical Fe reducing bacteria on soluble Fe and Fe/P ratio. Our results showed that, in the cyanobacteria-dominated open water zone, *Acidimicrobiaceae* was capable of Fe metabolism, contributing to the higher P flux in summer. In typical cyanobacteria-dominated bay, Sva0081 sediment group and *Desulfobulbaceae* could transform sulfate to sulfide which then cause the reduction of Fe (III), while in macrophyte-dominated zones, *Clostridium* sensu stricto 1 could couple oxidation of organic carbon with the reduction of Fe (III). The present study contributes new knowledge linking the bacterial communities with the physicochemical cycles of Fe and P in sediments under different primary producer habitats.

S25-O Characterization of particulate phosphorus classes in a eutrophic lake by 31P-NMR spectroscopy. *Xiuling Bai, Jinhua Sun, Yunkai Zhou*

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Phosphorus (P) is a biologically active element, and it plays a central role in controlling algae bloom formation, which may pose a serious threat to freshwater ecosystems. Characterization of P pools is vital to understanding the contribution of P to water eutrophication. We used solution ^{31}P-NMR to characterize the classes of particulate P compounds, as well as their temporal and spatial variations, in eutrophic Lake Taihu, Eastern China.

Results showed that the classes of particulate P mainly consist of orthophosphate (Ortho-P), orthophosphate monoesters (Mono-P), orthophosphate disters (Diester-P) and pyrophosphate (Pyro-P). The temporal variation trends of the main particulate P calsses were the same in different lake regions. As for the spatial variations of particulate P, the proportions of various classes of P compounds in particulate total P were relatively stable. During the algae bloom, the significant positive correlations between the major particulate P classes and Chl *a* during majority of the sampling period, indicated that living algal cells have a major contribution to particulate P.

Obvious temporal variations of P classes may effect the bioavailability and dynamics of P in the water of Lake Taihu, but the particle reactivity of the main inorganic and organic P classes were similar, therefore, they have little effect on P partitioning between dissolved and particulate phases. Diester-P:Mono-P and Diester-P:Pyro-P in particulate P are lower than those in sediment P. Based on the conceptual model of P groups, changes of Diester-P by microbial activity may be responsible for the difference in the relative abundance of dominant P classes in different carriers in Lake Taihu.

S25-O Combined effects of Phoslock® and submerged macrophyte on sedimentary phosphorus inactivation.

Xiumei Zhang

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Restoration of submerged macrophyte is an important means of lake ecosystem reconstruction. However, submerged macrophyte cannot maintain clear water when the internal phosphorus release is extreme high. Lanthanum (La) modified bentonite (Phoslock®), an increasing used phosphorus (P) inactivator, may help to solve this tough thing without damage to submerged macrophytes. In this paper, we investigated the efficacy of Phoslock® and a submerged macrophyte (*Vallisneria denseserrulata*), alone and combined to sediment P inactivation. Based on the mobile P content in the upper 5 cm of the sediment, 270 g of Phoslock® was added to related the experimental units, and the water quality and sediment P were monitored for 3 months. Diffusive gradients in thin films (DGT) was employed to measure labile P in overlying water-sediment profiles. The results showed that the DGT-labile P decreased with time in all treatments. The decrease in combination treatment was faster than other two single treatment. H_2O-P and BD-P in the treatments with Phoslcok® addition, decreased more obviously than others. HCl-P in the treatment with both Phoslcok® and macrophyte increased noticeably, especially in the depth below 4cm. The macrophytes in the treatment with Phoslock® addition had more shoots and leaves than without. The biomass had no significant difference between these two treatments. Here we draw the conclusion that Phoslock® can help macrophyte to make sediment P into stable fraction but without damage on the growth.

S25-O Biogeochemical cycling of Mercury in the Nansi Lake, China.

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Nansi Lake is located at southwest of Shandong Province, China, which is consists of four sub-lakes: Nanyang lake, Dushan Lake, Zhaoyang Lake and Weishan Lake. A survey from Nansi Lake was conduct to evaluate the mercury (Hg) concentration and distribution characteristics in water, sediments, fishes and aquatic invertebrates. Results showed that total mercury (THg) and Methylmercury (MeHg) concentration in Nansi Lake ranged from 2.95 to 6.83ng/L and 0.16 to 0.25ng/L, respectively. The total dissolved mercury (DTHg) concentration in the pore water of sediments was 1.98-12.52 ng/L, which is obviously higher than the overlying water. The diffusion flux of the sediment water interface was 71.5ng/m^2/day and 29.9ng/m^2/day, indicated that the release of Hg from sediments may also be an important source to the overlying water. The THg and MeHg concentration ranged from 17.30 to 88.10μg/kg and 0.12 to 1.03μg/kg, respectively. Elevated THg and MeHg concentration was observed in surface sediments, which indicated that the Hg pollution of the Nansi Lake was aggravated in recent years. The concentration of THg and MeHg were positively correlated with total carbon (TC) and total nitrogen (TN) ($P<0.01$), and the C/N radio showed the organic matter was mainly from the terrestrial input. The MeHg/THg were ranged from 0.4 to 1.8%, and the maximum appeared in surface, suggested that the surface environment may be fit for mercury methylation. THg and MeHg in fish and aquatic invertebrates was not exceeded the WHO limit for THg in fish (500 ng/g), and the risk assessment showed that the consumption of fish would not exceed the daily intake recommended by USEPA and WHO.

S25-O Assessment of Cr pollution in sediments combining geochemical baseline and in situ DGT.

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The geochemistry behavior of trace metals in sediment and water is of key importance in understanding metal pollution in aquatic environments. As the predominant aquatic carcinogens, Cr in the water or sediment has been widely studied. However, its fate at the sediment-water interface (SWI) is still not completely understood, especially in large reservoirs. The Three Gorges Reservoir (TGR) is the world's largest man-made hydroelectric station and the largest drinking water reservoir in China In this study, sediment cores and surface water samples were collected in the two tributaries and the mainstream in the TGR in order to investigate the mobility and release trends of Cr in TGR sediments. The geochemical baseline along with the diffusive gradients in thin films (DGT) was first applied to comprehensively evaluate the risk of sediment Cr being released into water in the TGR. Results showed that Cr in surface water poses carcinogenic risks, although average concentrations were within the corresponding standard in China. The geochemical baseline of Cr (85.53 mg/kg) was calculated and lower than the average concentrations of Cr in the sediments (89.60 mg/kg). The Cr contamination evaluated by the geochemical baseline value indicated that generally 48.78% of samples have been polluted by anthropogenic activities. The most contaminated sampling sites were located in the Meixi and Yangtze Rivers. However, risk assessments (geoaccumulation index, potential ecological risk and enrichment factor) based on the geochemical baseline and the background value showed that TGR sediment originated mainly from natural sources. The C_{DGT}-Cr values were in the range of 0.41-1.83 μg/L. Combining the geochemical baseline and net diffusive gradient at the SWI indicated that only Cr in the upstream of the Meixi River was at risk of being released into the overlying water. Therefore, combining geochemical baseline and DGT is an effective indicator in assessing sedimentary Cr pollution.

S25-O Spatial variations of heavy metal contamination in riparian sediments after two years' water-level regulation in the Three Gorges Reservoir, China.

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In this study, six heavy metals (Cd, Cr, Cu, Ni, Pb and Zn) in the mainstream riparian sediments of the entire Three Gorges Reservoir (TGR) were investigated in 2014 and 2016 to identify their contamination and risk characteristics and decipher the main factors for the variation of the metal contamination. The results showed that the concentrations of the metals in the sediments did not vary significantly between 2014 and 2016, and their contamination degrees decreased in the order of Cd>>Cu≈Zn>Pb>Cr≈Ni in 2014 and Cd>>Zn>Cu≈Pb>Cr≈Ni in 2016. The potential eco-risk of Cd was extremely high in the two years, while the eco-risk of other metals was very low. The sediments showed a moderate to high contamination level, a high potential eco-risk but a low toxic risk to aquatic biota in the two years. Spatially, the contamination and risk levels of heavy metals were relatively higher in the downstream TGR regions in 2014 but in the central TGR regions in 2016. Much more anthropogenic contributions in 2016 than in 2014 increasingly contributed to the high contamination and risk levels of Cd, Cu, Pb and Zn in the central regions. The results indicate that the Cd contamination in the riparian sediments of the TGR is still a vital environmental issue, and the decreased sediment inputs from the upstream TGR regions, the periodic and anti-seasonal water-level regulation, local geomorphological characteristics and anthropogenic activities determine the contamination distribution of heavy metals in the sediments.

S25-O Assessing heavy metal pollution in the sediment of main inflows of Dongting Lake, China.

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Heavy metal pollution in the sediment is one of the most serious problems facing rivers, which can lead to secondary pollution when environmental conditions change. In this study, surface sediment samples collected from different sections of Xiangjiang River (XR), Zishui River (ZR), Yuanjiang River (ZR) and Lishui River (LR), which were the main inflows of Dongting Lake, were analyzed for metals of Zn, Cr, Cu, As, Cd and Pb. The spatial distribution, source and potential ecological risk of these metals were determined. The concentration of heavy metals descended in the order of Zn > Pb > Cr > Cu > As >Cd, which is especially highest in XR, and lowest in LR. Most metals had higher concentration in the midstream and downstream of these rivers. The PCA and correlation analysis indicated that Cd and As were mainly from industrial wastewater, Cr and Pb came from natural process and agricultural activities, Zn and Cu might mainly from the mutual sources. According to the I_{geo}, EF and RI assessment, the potential ecological risk was highest in XR and Cd was at highest ecological risk. Therefore, more attention should be paid to XR and Cd in the inflows to alleviate the sediment pollution.

S25-O Geochemical baseline establishment and pollution source determination of heavy metals by statistical approach in sediments in Lake Lihu, China.

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Geochemical baseline represents the relative natural change of the heavy metal contents in studied sediments in the present or certain period. Baseline, as the boundary between the background values and the anomalous ones, is able to evaluate the future change of environmental quality as the reference. In this study, the geochemical baseline values of surface and core sediments in Lake Lihu, a typical urban lake in Lake Taihu Basin, were analyzed and compared by cumulative frequency and iterative 2σ methods. The enrichment degree and pollution type of the heavy metals in surface sediments were also determined. The baseline values of metals in sediments calculated by cumulative frequency and iterative 2σ methods, did not show significant ($P>0.05$) difference. The geochemical baseline of core sediments represented the background concentrations of local sediments. The enrichment levels of Zn, As and Pb were relative higher than the other tested metals in the surface sediments. The enrichments of Pb and Zn were mainly caused by point source pollution, which contributed 76.03% and 61.96% to the total amount of human interference, respectively. The contents of Pb and Zn induced by point source pollution were 1.99 and 1.63 times as much as the background values, respectively. Contributions of point and non-point pollution to the enrichment of As were almost equal, and non-point source pollution accounted for 47.36% of the total amount of human interference.

S25-O Discrimination of rare earth geochemistry, co-occurrence, and provenance in sediment from Poyang Lake, the largest freshwater lake in China.

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Rare earth elements (REEs) have been used as geochemical tracers to study a variety of environmental processes. Here, both surface sediment and sediment core samples were collected from Poyang Lake, the largest freshwater lake located in the middle-low region of the Yangtze River samples were analyzed for their respective REE spatial distributions, fractionation, and co-occurrence patterns. Results indicated that total REE concentrations in the sediments from Poyang Lake ranged from 145.1 to 351.1 μg g^{-1}, with an average concentration of 254.0 μg g^{-1}. Light REE enrichment was evident in all sediment samples, indicating the effects of river-lake interactions and terrestrial inputs. Slightly negative Ce and Eu anomalies were found in most sediment samples, indicating differentiation in sediment transportation and deposition between Ce, Eu, and other REEs. Collectively, co-occurrence and REE fractionation pattern analyses revealed that the sediments originated from a variety of sources.

S25-O Mechanisms driving phosphorus release during algal blooms based on hourly changes in iron and phosphorus concentrations in sediments.

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Algal growth causes a drastic change in aquatic conditions over a diel cycle, which may induce sensitive feedback systems in sediments, causing P release. In this study, a microcosm experiment was performed using a suction sampler (Rhizon) to observe changes in soluble reactive phosphorus (SRP) and soluble Fe(II) concentrations in the top 20 mm sediment layer on a 3-hour time interval, at different phases of harmful algal blooms (HABs) development. The results showed that the algal blooms prevailed up to 15 days after incubation, after which the process of bloom collapse proceeded until the 70th day. The concentrations of pore-water soluble Fe(II) and SRP increased throughout the incubation period. Compared to day 1, maximum increases of 214% in soluble Fe(II) and 387% in SRP were observed at night during the bloom and collapse periods, respectively. The diffusive fluxes of Fe and P at the sediment-water interface (SWI) generally corresponded to their changes in concentrations. Hourly fluctuation in soluble Fe(II) and SRP concentrations were observed with two distinct concentration peaks occurred at 21:00 pm and 06:00 am (or 03:00 am), respectively. These findings suggest that Fe-P coupling mechanisms are responsible for the release of P from sediments. During the collapse period, soluble Fe(II) concentrations were suppressed by the increase of labile S(-II) at night. Meanwhile, SRP concentrations were decoupled from Fe cycling with small fluctuations (< 11% RSD) on an hourly timescale, and the decomposition of algae was a dominant source contributing to the release of P from sediments. These results significantly improved the understanding of processes and mechanisms behind the stimulated release of P from sediments during HABs.

S25-P Extraction, characterization and adsorption behavior of sedimentary colloids in eutrophic shallow lakes.

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Colloidal particles are ubiquitous in lake sediments and significantly influence the retention, transportation, and fate of contaminants in lake ecosystems. Here, the extraction, characterization and adsorption behavior of colloids (including total and inorganic colloid) from macrophyte- and algae-dominant lake sediments, were for the first time investigated. Results showed that the extraction efficiencies of sedimentary colloids increased with increasing ultrasonic intensities, and the algae-dominant sediments generally contained higher colloid amounts than the macrophyte-dominant sediments. Despite the different ecosystems, these sedimentary colloids were characterized with a size range of 30~200 nm, and contained the spherical, polygonal and elliptical shapes and ferric-, aluminum-, and silicon-containing mineralogical structures. Batch experiment showed that the total natural colloids exhibited higher adsorption capacity for Pb(II) than the inorganic colloids both for the macrophyte- and algae-dominant sediments, and the adsorption process followed the Langmuir isotherm and pseudo-second-order kinetics. Thus, sedimentary colloids can immobilize the heavy metals in sediment and decrease their release into the water column, which can be considered as a sink for contaminants. This study highlighted the significance of sedimentary colloids in determining the physicochemical properties of lake sediments and in evaluating the environmental behavior and fate of contaminants in lake ecosystems.

S25-P Internal phosphorus loading from sediments causes seasonal nitrogen limitation for harmful algal blooms.

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It is proposed that the internal loading of phosphorus (P) from sediments plays an important role in seasonal nitrogen (N) limitation for harmful algal blooms (HABs), although there is a lack of experimental evidence. In this study, an eutrophic bay from the large and shallow Lake Taihu was studied for investigating the contribution of internal P to N limitation over one-year field sampling (February 2016 to January 2017). A prebloom-bloom period was identified from February to August according to the increase in Chl*a* concentration in the water column, during which the ratio of total N to total P (TN/TP) exponentially decreased with month from 43.4 to 7.4. High-resolution dialysis (HR-Peeper) and diffusive gradients in thin films (DGT) analysis showed large variations in the vertical distribution of mobile P (SRP and DGT-labile P) in sediments, resulting in the SRP diffusion flux at the sediment-water interface ranging from -0.01 to 6.76 $mg/m^2/d$ (minus sign denotes downward flux). Significant and linear correlations existed between SRP and soluble Fe(II) concentrations in pore water, reflecting that the spatial-temporal variation in mobile P was controlled by microbe-mediated Fe redox cycling. Mass estimation showed that the cumulative flux of SRP from sediments accounted for 54% of the increase in TP observed in the water column during the prebloom-bloom period. These findings are supported by the significantly negative correlation ($p<0.01$) observed between sediment SRP flux and water column TN/TP during the same period. Overall, these results provide solid evidence for the major role of internal P loading in causing N limitation during the prebloom-bloom period.

S25-P Effects of decabromodiphenyl ether on activity, abundance and community composition of phosphate solubilizing bacteria in eutrophic lake sediments.

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Polybrominated diphenyl ethers (PBDEs) are a typical persistent organic pollutants in the environment, especially in sediments of aquatic ecosystems. Previous studies on PBDEs mostly focused on their environmental distribution and bioaccumulation in plants, animals and human, little is known about their effects on microbes, despite the fact that microbes play critical roles in element biogeochemical cycling. Taihu Lake, a typical eutrophic lake, has been contaminated by PBDEs, with a dominant congener of BDE-209 in its sediment. Taihu Lake sediment is also a sink of phosphate, which would be released into the overlying water by phosphate solubilizing bacteria (PSB) and then result in increased eutrophication. However, the PBDE effects on phosphate release from the sediments, as well as the microbial mechanism behinds, is still unknown Here, a microcosm experiment was conducted to examine the effects of BDE-209, at two contamination levels, 2 and 20 mg kg^{-1} dry weight representing low and high contamination level, respectively, on the activity, abundance, diversity and community composition of PSB in Taihu Lake sediment. At the end of 60-day experiment, both phosphate concentration of overlying water and available phosphorus of sediment were significantly increased due to BDE-209 contamination, irrespective of contamination level. Such increase might be explained by the stimulatory effects of BDE-209 on alkaline phosphatase activity, abundance of PBS. Moreover, based on the Miseq sequencing of *phoD* gene that encodes alkaline phosphatase, BDE-209 also significantly increased the diversity of PBS and altered their community composition. In particularly, the PBS genera *Comamonas*, *Luteipulveratus* and *Bradyrhizobium* were enriched by BDE-209 at the end of 60-day experiment. This study suggested the enhancement effects of PBDE contamination on phosphate release from the eutrophic lake sediments by stimulating the activity and growth of PBS.

S25-P Role of Stable Fine-sand Capping Layer on Surface Polluted Sediments in Decreasing Nutrients in Water Column of Wuhan Donghu Lake of China.

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Capping technique with clean sands is widely applied to retard the release of nutrients in contaminated sediments. However, the mechanism remains unclear. Using fine sand and geotextile as capping materials and sediments sampled from Wuhan Donghu Lake of China, we constructed simulation capping experiments with different coverage degree, and continuously monitored TN, TP, NO_3^-–N and SRP in the water column for approximate 9 months. The results showed that changes of TN, TP, NO_3^-–N and SRP were composed of three successive processes, e.g. decreasing, increasing and re-decreasing. Sand capping of surface sediments by different coverage degrees does not alter the dynamic tendencies of nutrients in the water column, but overall decreases their minima, maxima and mean concentrations with the water quality elevated in a different extent. The higher coverage degree and the lower is the same nutrient decreased. To evaluate the role of capping layer in controlling nutrients in water column, the apparent fluxes of nutrients through sediment-water interface were calculated during sediments as sink and source. Sand capping significantly promoted the migration of TN toward surface sediments with TN in the water column decreasing when sediment acts as a sink. When sediment acted as a source, sand layer to block release of TN was not obvious. Sand capping layer mainly blocked release of TP in sediments. For NO_3^- and SRP, sand capping obviously intensifies potential of surface sediments to buffer them. When sediment acts as a sink, more NO_3^- and SRP in the water column returns to sediment, less of them are released while acting as a source. Mineral component analysis suggested enrichment of iron oxides is responsible for role of sand capping layer in decreasing

nutrients in water column.

S25-P The influence of dredging on the concentration and occurrence forms of Cr in Meiliang Bay of Lake Taihu. *Shuaishuai Gao*

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Sediment dredging was considered as one of the effective means for the treatment of contaminated sediment. To study the effect of dredging on the concentration and morphology of heavy metal Cr in Meiliang Bay of Lake Taihu, the monthly sampling of dredging and non dredging points in Meiliang Bay were carried out. The high-resolution dialysis (HR-Peeper) and the diffusive gradients in thin films (DGT) technique and BCR continuous extraction method were used to detect soluble Cr and DGT-labile Cr (VI) at a vertical resolution of 4.0 mm and occurrence forms in sediments, respectively. As for soluble Cr, the results showed that the concentration of Cr in dredged site in July 2016 and January 2017 was significantly higher than that in April and October 2016. In July 2016 and January 2017, the Cr concentration of dredging points was significantly higher than that of the non dredged site. It indicated that dredging could reduce the concentration of soluble Cr when the Cr concentration was high in the lake. As for DGT-labile Cr(VI), the concentration of Cr far less than peeper, the concentration of Cr increased from April 2016 to January 2017, and the Cr concentration of dredging site was larger than that of the undredged site. As for chromium occurrence forms, except individual depths, the Cr concentration of dredging site including the total amount of Cr, water-soluble exchangeable carbonate-bound Cr, ferric oxide bound Cr, organic and sulfide-bound Cr and residual Cr were all higher than those of the undredged site. It indicated that dredging could increase the concentration of different forms of Cr in sediments. This study provided a certain basis for the treatment of Cr in the future.

S25-P The effect of calcium nitrate, bio-energizer and submersed macrophyte on microbial community composition changes in black and odorous sediment of urban river. *Zongan Jin[1], Zejun Liu[1], Yali Tang[1], Zhenwen Liu[2]*

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To analysis the effect of calcium nitrate (group CN), bio-energizer (group BE) and submersed macrophyte (*Vallisneria natanson*, group Mac) on microbial community composition changes in black and odorous sediment of urban river. A simulated experiment was designed to investigate the effects of different remediation technologies on bacteria structure composition, especially the functional groups in sediment. Results showed that the abundance of bacteria in the sediment of different experimental groups were between 6.18×10^5~2.97×10^6 copies/g; The bacterial abundance in group Mac and group CN is less than the control group, while bacterial abundance in group BE has slightly increased than the control group. High throughput sequencing revealed a total of 55 phyla, 130 classes and 802 genuses of bacteria. SIMPER analysis on the genus level indicated that Ferribacterium, Clostridium, *Anaerolineaceae* sp., *Xanthomonadales* sp. are the bacteria causing microbial community dissimilarities. When compared with the control group, the abundance of these bacteria in three treatment groups are significantly decreased (p<0.05); the analysis of potential special functional bacteria in different experimental groups implied that when compared to control group, with the exception of the sulfate-reducing bacteria in the BE group, the potential black and odour causing bacteria group had different degrees of reduction in all treatment group. The abundance of potential reduction bacteria in group Mac was 2.36×10^4, which is less than that in the control group, but no significant difference (p>0.05); group CN and group BE are higher than that of the control group, $7.23\times10^4$and 1.36×10^5, respectively. Redundancy

analysis (RDA analysis) showed that the redox potential and pH of the sediment might be the main environmental factors affecting the microorganism community structure.

S26. Strategies for saving large lakes threatened by nutrient over-enrichment and climate change

S26-O Why Large Shallow Eutrophic Lakes Resistance to Restoration?

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Since the notorious drinking water crisis in 2007 caused by a massive toxic cyanobacterial bloom in Lake Taihu, China, a ten-year program aimed at diverting nutrient inputs to the lake has yielded little improvement in bloom intensity. Improvement of water quality and bloom mitigation has proven to be difficult in such large shallow system because of the large scale; a holistic comprehensive watershed-scale management approach will be crucial for lake restoration and long-term protection efforts.

S26-O Lakes in trouble - Understanding the effect of climate change on threatened ecosystem services of Lake Taihu (China) and Lake Pyhäjärvi Finland.

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Lakes in trouble project focused on linking hydrologic, biological and biogeochemical changes with underlying climatological drivers in two geographically distinct but functionally relatively similar shallow systems, Lake Pyhäjärvi in Finland and Lake Taihu in China. The project had a holistic approach including paleolimnological and long-term monitoring data on the aquatic systems and in situ and modelling approaches on internal loading and nutrient dynamics in shallow lakes under different climate change scenarios. In our paleolimnological studies we compared lakes in Finland and in China with different land use patterns and we found ecosystem scale changes in both countries. The land use impact was clear in China, but found also in Finland. Phytoplankton community study with data mining was made and we found large scale changes: In Finland the changes were related to climatic variation, in China more to urban impact. Wave measurements were made with the techniques that have not been earlier used in Finland. This data was linked with hydrological modelling and more exact estimates of internal load were provided. Resuspension measurements were made in both lakes and the main result is that macrophytes have stabilizing effect on resuspension. The restoration aims and implementation in study lakes were compared. The conclusion was, that climate change will challenge the restoration work both in China and Finland. In Finland, climate change will influence the effectiveness of water protection measures, as the timing and intensity of external load will and have already changed. In China the land use and human impact is the main challenge, although the climate will have impact on lake management also there, especially in agricultural catchments. Thus, climate change will and has already affected the ecosystem services of these lakes. Knowledge exchange and new ideas are needed and the meaning of international multidisciplinary co-operation will increase.

S26-O Long-term phytoplankton structure succession responded to nutrient and climate changes in large shallow Lake Taihu, China.

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Based on the 8 sampling investigations in Lake Taihu during 1992-2017, the phytoplankton community structure and successions were discussed. Analysis revealed that the dominant species of phytoplankton community had changed remarkably from green algae in 1960s to diatom in 1981 to blue-green algae after 1988. The cyanobacteria remained dominant all the time in the recent 25 years. Detailed data indicated that *Microcystis* blooms occurred earlier and lasted longer which caused unclear seasonal dominated species changes of the phytoplankton groups in Lake Taihu in recent years. A nearly mono-specific bloom of *Microcystis* dominates the phytoplankton during summers, autumn, spring, and even winter in Lake Taihu. The proliferation and outburst of phytoplankton bloom were impacted by nutrient availability, as well as climatic and meteorological conditions. Shallow lakes like Taihu were sensitive to climate change, like changes in the thermal regime, rather than direct temperature effects, which could positively influence cyanobacteria dominance.

S26-O Increased P limitation of algal growth and no change in algal biomass following increased nitrogen concentrations in Lake Taupo.

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Lake Taupo, iconic for its dramatic volcanic setting and crystal clear waters (mean annual chlorophyll *a* 1 µg/L, Secchi 15 m), is New Zealand's largest (616 km^2, 167 m max. depth) lake. Taupo is the only large lake in the world currently under a nitrogen (only) loading cap operating since 2011 to protect the lake's water quality. The choice to cap N was based on low total nutrient TN:TP ratios, low NO_3:SRP ratios and enrichment bioassays most recently done in 2001 which concluded that N limited algal growth in Lake Taupo. We evaluated the nutrient status of Taupo in the summer of 2015 and in September 2016 - June 2017 and found strong evidence of P deficiency whereas none had been found in 2001. There has been no trend in P concentrations since 2001 and chlorophyll *a* has also remained low despite evidence for increased N concentrations since 2001. Taupo phytoplankton are now more deficient in P than in 2001, and P as well as N may be limiting algal biomass. The TN:TP molar ratio in Lake Taupo changed from 31 in 2001 to 38 at present, while the particulate N:P ratio increased from 18 to 28. Our results question the efficacy of nutrient enrichment bioassay results to predict how lakes will respond to changes in nutrient loading and suggest that managing P loading should be the primary management strategy to control algal biomass in lakes.

S26-O Water quality trends and eutrophication control in the Three Gorges Reservoir region before and after impoundment.

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Reservoirs are essential for the wellbeing of human societies, but can also be subject to negative ecological impacts. The Three Gorges Reservoir (TGR) in the upper Yangtze River is remarkable for its size and engineering; however, its effects on water quality are poorly understood. This study is the first to describe long-term (1992-2016) monitoring results for chemical oxygen demand (COD, via the potassium permanganate index), total phosphorus (TP), total nitrogen (TN) and ammonium (NH_4-N). The results is show that the COD and TP between impoundment in June 2003 and 2016, have decreased 40.9% ± 9.9% and 22.2% ± 9.7% in the TGR mainstream, respectively, while TN and NH_4-N have increased 1.3% ± 2.4% and 8.2% ± 2.6%. In addition, phytoplankton biomass has increased by a factor of 2.7 (1.1-4.8) over pre-impoundment levels in the mainstream, and tributary algal blooms have increased in frequency since 2004. The reductions in COD and TP were caused primarily by decreases in water flow speed, which lead to sediment settlement. TN and ammonium are less affected by sediment deposition and have increased slightly under intensified human activities. Decreased water flow

speeds and nutrient enrichment have promoted increases in algal biomass, leading to blooms in tributary backwater zones. In situ experiments indicate that phytoplankton growth in the TGR is phosphorus limited during all seasons. Therefore, controlling phosphorus will reduce the short-term eutrophication potential in the reservoir. However, concurrent control of nitrogen and phosphorus inputs are necessary in the long term.

S26-O Combating large lake eutrophication and harmful algal blooms in the anthropocene: Why dual nutrient (N &P) reductions are needed.

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Accelerating eutrophication and proliferating cyanobacterial blooms (CyanoHABs) pose a serious global environmental and human health problem that is now threatening the world's large lake and reservoir ecosystems. Human nutrient enrichment and hydrologic modifications, including dam and reservoir construction and diversions, are major drivers of bloom expansion. However, climatic changes, including warming, extreme rainfall and drought events, and lower wind speeds over time act synergistically with these drivers to exacerbate the problem. Traditionally, P reductions have been prescribed for combating freshwater eutrophication, but only reducing P inputs will not yield a "quick fix" because most large lakes/reservoirs already have a >30 year legacy of excessive P loading. Reducing N inputs in addition to P will speed up the recovery period, because the removal of N loads through in-lake denitrification can cause N limitation under bloom conditions, making the system sensitive to new N inputs. Experimental evidence from Lake Taihu, China indicates that decreasing N inputs will significantly reduce cyanobacterial biomass without replacing non-N_2 fixing with N_2 fixing species. Over time, sustained reductions in both N and P discharge aimed at reducing trophic state and CyanoHAB control can be accomplished by constructing riparian vegetative buffers and developing upstream and lake-associated wetlands, improving fertilizer and agricultural waste management, and minimizing urban wastewater and storm water runoff. Flexible nutrient reduction approaches are needed to mitigate waters impaired by CyanoHABs, and they should be an integral component of nutrient management strategies because, as climatic influences change, and internal nutrient loading decreases over time, new nutrient-bloom thresholds will likely emerge.

S26-O Threatens on water quality in Xinanjiang Reservoir, China.

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Lake Qiandaohu, or Xinanjiang Reservoir, is a huge reservoir serving as drinking water resources of Hangzhou City. Seasonal diatom and cyanobacterial proliferation, however, threatened the water quality in recent years, caused by more extreme climate conditions and catchment development. Since 2013, annual water quality report has been produced by Nanjing

Institute of Geography and Limnology. The water quality status and its possible influencing factors were analyzed every year. Because the hydrological residential time is around 2 years, the water quality of the reservoir shows highly spatial and temporal variation. In early spring rain season, the inflows carry plenty of suspended particles and phosphorus into the reservoir. This frequently causing higher total phosphorus concentration than the target level at the national control monitor sites. Diatom proliferation during later spring and cyanobacterial proliferation during early summer also significantly increase the total phosphorus and nitrogen concentration in surface water bodies. This monitoring suggests that land exploration control is crucial to decrease the seasonal high nutrient level. The extreme weather condition events also cause high bloom risk for the reservoir even that the water quality keeps at good status.

S26-O Hydrologic changes regulate phytoplankton species composition and repress seasonality in subtropical shallow lakes in Florida USA.

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Rainfall onto the Florida peninsula is linked with the Pacific Sea Surface Temperature Anomaly, and the depth and flushing rate of shallow lakes are determined by rainfall. We analyzed the influence of two cycles of variation in rainfall using a 10-year data set from a six shallow eutrophic lake lacking submerged vegetation and dominated by phytoplankton. Both cluster analysis and nonmetric multidimensional scaling (NMDS) based on Bray & Curtis' dissimilarity matrices were employed to explore the possible phytoplankton community composition seasonality and periodic pattern. Our results provide evidence of hydrologic changes regulating the succession of phytoplankton species composition. Depth, which was hysteretically controlled by rainfall, was the most important variable and flushing was a synergistic one. The species compositions were similar and relatively stable regardless of temperature variation during the similar hydrologic situations. When depth varied, species composition changed, and it persisted in a different state when depth was stable. A seasonality of phytoplankton was absent because of the intermittent hydrologic interruption. The phytoplankton species composition changing along with hydrology complicates the management of shallow lakes. The results provide insight into how climate variation might affect phytoplankton composition and bloom management in nutrient-enriched shallow lakes.

S26-O Multi-annual dominance patterns of Dolichospermum and *Microcystis* in the hypereutrophic Lake Taihu, China.

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Dolichospermum and *Microcystis* are common toxin-producing cyanobacteria that frequently cause seasonal blooms in eutrophic freshwaters. *Microcystis*-induced blooms occurred annually in Lake Taihu. However, the *Dolichospermum* biomass increased significantly in recent years. To understand the factors driving the succession between *Dolichospermum* and *Microcystis*, monthly (2012 to 2016) and weekly (from March to June 2016) monitoring of phytoplankton and water quality in northern Lake Taihu were conducted. The results showed that the cyanobacterial bloom changed from *Microcystis* dominance during 2012 to 2015, to an alternating bloom succession of *Dolichospermum* and *Microcystis* in 2016. *Dolichospermum* was present with low dominance from 2012 to 2015, and no bloom was found. However, the dominance and duration of the *Dolichospermum* increased significantly and formed bloom in early spring 2016. The stepwise

multiple regressions demonstrated that the increased of accumulated water temperature (AWT), high dissolved total phosphorus (DTP) and high water level (WL) during the preceding winter were the primary variables promoting the *Dolichospermum* bloom in early spring 2016, whereas water temperature was the main factor driving the bloom shift from *Dolichospermum* to *Microcystis* in 2016. The increase of *Dolichospermum* dominance may be problematic in freshwaters, because *Dolichospermum* could produce different cyanotoxins from *Microcystis*, and also has significantly different nutrient utilization and cycling processes. Hence, long-term countermeasures to control these two harmful cyanobacteria could differ. These results suggest that water quality management for controlling diverse harmful cyanobacterial blooms will face new challenges as climatic changes take place.

S26-O Nutrient pollution and critical thresholds for Chinese lakes: a case of Lake Taihu.

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China has gone through a vast development of economy, human population and society. Whilst this vast development has strengthened China's international position, it has also resulted in environmental issues including eutrophication of lakes. As a result many Chinese lakes experience turbid waters with toxic cyanobacteria blooms including Lake Taihu. These cyanobacterial blooms are detrimental to ecosystem services such as the provisioning of water for drinking and irrigation, and to food supply and tourism. To prevent eutrophication to impede China's future sustainable development, it is important to understand the possible consequences of eutrophication of freshwater lakes. In this respect, two important aspects need to be addressed. The first aspect is to determine current nutrient loads to lakes from all sources. Nutrient loads to lakes can be based on measurement data or estimated by models such as MARINA. The second aspect is to determine the critical nutrient load of the specific lake that marks the threshold between clear and turbid water. Critical nutrient loads can be determined by ecosystem models like PCLake. By combining knowledge on the current load with the critical nutrient load, managers can define goals to reduce the nutrient load beyond the critical nutrient load

Here we focus on the assessment of the current and critical nutrient loads of Lake Taihu, a large shallow lake (area: 2250 km², average depth: 2 m) that is located in southeast China. This lake became hypereutrophic during last decades. Depending on the maximum allowable chlorophyll-a concentrations, our results show that 50-90% of the current nutrient load to Taihu has to be reduced to reach sufficient water quality. We compare this output with findings for other Chinese lakes. This knowledge is valuable for sustainable development in China.

S26-O A novel single-papameter approach for porecasting algal bloom.

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Harmful algal blooms frequently occur globally, and forecasting could constitute an essential proactive strategy for bloom control. To decrease the cost of aquatic environmental monitoring and increase the accuracy of bloom forecasting, a novel single-parameter approach combining wavelet analysis with artificial neural networks (WNN) was developed and verified based on daily online monitoring datasets of algal density. Firstly, a detailed modeling process was illustrated using the forecasting of cyanobacterial cell density in the Chinese reservoir as an example. Three WNN models occupying various prediction time intervals were optimized through model training using an early stopped training approach. All models performed well in fitting historical data and predicting the dynamics of cyanobacterial cell density, with the best model predicting cyanobacteria density one-day ahead ($r = 0.986$ and mean absolute error = 0.103×10^4 cells mL^{-1}). Secondly, the potential of this novel approach was further confirmed by the precise predictions of algal biomass dynamics measured as Chl *a* in both study sites, demonstrating its high performance in forecasting algal blooms, including cyanobacteria as well as other blooming species. Thirdly, the WNN model was compared to current algal forecasting methods (i.e. artificial neural networks, autoregressive integrated moving average model), and was found to be more accurate.

S26-O Title: Recycled N as a driver of cyanobacterial harmful algal blooms in three large eutrophic lakes (Taihu, Okeechobee, and Erie): lessons for nutrient management practices.

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Non-N_2 fixing cyanobacteria, such as *Microcystis* and *Planktothrix*, thrive on chemically reduced N forms (NH_4^+ and urea). Thus, NH_4^+ dynamics and turnover rates are important components of the aquatic N cycle in eutrophic lakes affected by cyanobacterial harmful algal blooms (cyanoHABs). Regeneration of NH_4^+ drives internal cycling of NH_4^+, which can sustain cyanoHABs when in situ N is depleted. Lakes Taihu (China), Okeechobee (Florida), and Sandusky Bay (Lake Erie, USA) have been experiencing cyanoHABs associated with high external inputs of reduced N and P. We report NH_4^+ uptake and regeneration rates from these three ecosystems, using a well-established method of ^{15}N-NH_4^+ isotope dilution experiments. To investigate the importance of internal N cycling, we compared the external N loadings and extrapolated internal NH_4^+ regeneration rates. Such comparison in Lake Taihu showed that whole-lake NH_4^+ regeneration supplied almost twice as much NH_4^+ than the reported external NH_4^+ loadings. Similar extrapolation in Lake Okeechobee showed that in 2016, regeneration introduced 3.07×10^5 metric tons of reduced N, two orders of magnitude more than reported TN loadings. In Sandusky Bay, TN loading from the Sandusky River introduced 8.58×10^3 metric tons of N into the bay annually, while average summer regeneration alone recycled 6.6×10^3 metric tons of N as NH_4^+. In just the three summer months evaluated, regeneration in the water column provided bioavailable N for primary production at the level of ~77% of the annual N load. This exercise exemplifies the critical role of internally recycled NH_4^+ during summer in sustaining cyanoHABs, especially when ambient N is depleted. Quantifying N supply from internally recycled NH_4^+, driven by high external N loads, is critical information for resource managers and regulators, who often base management decisions on ecosystem models that do not sufficiently

consider the effects of N dynamics on eutrophication.

S26-O Vertical sediment migrations of dominant midge species in subtropical lakes with implications for bioassessment.

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Propsilocerus akamusi (Diptera: Chironomidae) is a dominant species in numerous eutrophic lakes and they could burrow into deep sediments (>30 cm) during summer months. However, common-used grab samplers are efficient in collecting surface-dwelling species (<20 cm), thus vertical migrations of dominant species may interfere bioassessment. Here, we monthly investigated the vertical sediment positioning of *P. akamusi* larvae and its influence on bioassessment. Our results indicated that, from late-April to October, most individuals aestivated at the sediment below 30 cm depth which maybe an adaptation to the thermal stress. As to other periods, the larvae were generally found in the depth of 10-30 cm. Moreover, Peterson grab samples collected only 0 % and 12.6 % of total *P. akamusi* individuals in summer and late-autumn, respectively, resulting in serious underestimation of the actual pollution status. This implied that vertical movements of dominant macroinvertebrates should be taken into account when designing of bioassessment protocols. For *P. akamusi*, Core-sampling for calibration were strongly encouraged, and the low-temperature period for Grab-sampling is also proposed.

S26-O Impacts of anthropic activities and climate change on Lake Bosten in arid northwestern China.

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Due to regional climate changes and increasing anthropic activities, water eutrophication and salinization continually impacts natural inland aquatic ecosystems of arid and semi-arid areas, and even threatens survival and development of human in these regions. As the largest freshwater lake located in northwestern China, Lake Bosten is facing the threats of eutrophication and salinization. Based on the analysis of long-term records of climate, nutrient and palaeolimnological data, here we present the succession of Lake Bosten ecosystem (including water quality, hydrophytes, phytoplankton, zooplankton, zoobenthos, bacterial communities, chironomus and diatom communities in sediments) and the effects of climate change (temperature and precipitation) and anthropic activities (agricultural activities and pollutants) on them. Our data showed that Lake Bosten was mainly controlled by natural succession before 1960s and the deterioration of this lake after 1960s was mainly resulted from combined effects of increased anthropic activities and climate changes.

S26-O Biological nitrogen recycling and translocation exceed physical transport fluxes in a large oligotrophic lake: A coupled mass balance and hydrodynamic model evaluation.

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Relationships between nutrient over-enrichment and eutrophication are well established for lakes but additional stressors such as climate warming make these less predictable. Both positive and negative feedbacks of warming on eutrophication have been presented in the literature with the effect of warming dependent on the relative importance of transport and biogeochemical fluxes on nutrient cycles. For example, in large deep lakes, warming reduces water column mixing resulting in reduced nutrient availability in the photic zone and lower productivity. By contrast, increasing water temperatures will increase metabolism in the epilimnion and produce greater nutrient recycling. Thus, quantifying the relative contributions of physical and biogeochemical fluxes for lake nutrient budgets is important for managing lake trophic status. Physical influxes of littoral nitrogen (N) into pelagic waters are known to be both substantial and variable, but are seldom considered in isolation. We used a three-dimensional hydrodynamic model to quantify littoral-pelagic exchanges over an annual cycle in Lake Taupō; a large (616 km^2), warm monomictic, oligotrophic lake in New Zealand. Modelled littoral-pelagic exchanges and respective N concentrations, together with phytoplankton N uptake and other major N influxes (e.g., atmospheric deposition, N-fixation, riverine inputs and consumer translocation of littoral sources into pelagic waters) were incorporated into the mass balance model. The model demonstrated that littoral-pelagic exchange acted as a net source of N to the pelagic surface waters throughout the year. The mass-balance model demonstrated, however, that consumer excretion of littoral-derived N exceeded the physical transport flux between the two zones during summer stratification (December and February). In situ recycling was the dominant N flux (> 70%), supporting pelagic primary production throughout the year. These results highlight the dominant role of biological interactions to recycle and transport nitrogen and drive phytoplankton production in lakes. The potential for recycling to amplify the eutrophying effect of nutrient inputs suggests that catchment nutrient limits should be more stringent. Furthermore, greater management emphasis should be placed on quantifying littoral and pelagic biotic processes, particularly in response to climate change, in large lakes.

S26-O Using big data to save large lakes – understanding what the microbial community is trying to do provides a path forward.

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The union of molecular ecology and limnology has led to new insight into factors that drive microbial communities (including viruses, bacteria and algae) in large lakes around the world. As these lakes continue to receive and respond to insults from anthropogenic stressors and climate variability, it becomes important to tease apart these multiple drivers of community trajectory, and in the process to look for both commonalities across lakes and unique responses within individual lakes. Using 3 billion environmental metatranscriptomic reads as well as metabolomics, lipidomics and targeted molecular tools from two heavily impacts lakes (Lakes Erie and Taihu),

we have been working to address questions concerning how the microbial community and in particular toxigenic cyanobacteria are responding to seasonal and spatial shifts in both abiotic and biotic factors. Our observations suggest that no individual factor (nutrients, temperature, pH, viruses) act as a sole driver of bloom events, but that a combination of stressors is the norm for the microbial community. The combined results of nearly a decade of analyses across hundreds of samples is leading us out of the shadow of "it's complicated", and beginning to point to specific commonalities that are linked to cyanobacteria bloom events in large lakes across the globe.

S26-O The roles of external loading and internal cycling of nutrients sup-porting harmful cyanobacterial blooms in Lake Taihu, China: Implications for nutrient management.

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Lake Taihu (Taihu) is the third largest freshwater lake in China. Harmful cyanobacterial blooms (CyanoHABs), reflecting advanced eutrophication, are creating serious threats to Taihu's drinking water supplies, ecological and economic sustainability. The proliferation of CyanoHABs is linked to increasing anthropogenic inputs and internal cycling of nutrients. Despite advances in understanding the role of external loadings, the relative importance of internal cycling remains unclear. We analyzed quarterly and monthly monitoring datasets from 2005-2015 to clarify seasonal N and P concentrations and inventories, and cyanobacterial biomass throughout the lake. TN and TP mass balances were established using riverine inputs and atmospheric inputs and export via multiple outlets, drinking water supplies, cyanobacterial harvesting, and fish harvest. TN and TP retention capacities were determined based on a mass balance approach using inventory data, and response of in-lake TN and TP and CyanoHABs to external nutrient reductions. The links between system-wide N loss via denitrification, P release from sediments and CyanoHAB potential were assessed. TN showed large seasonal variations, with higher values in winter and spring, and lower values in summer and fall. The lake retained 60-70% of the external load of both N and P. N loss via denitrification was 59% of external TN load. Spring-summer N loss spring due to denitrification reduced summertime bloom biomass by ~34%. Internal sediment P release contributed 31.5% of total TP supporting summer blooms. Reversal of hypereutrophic conditions by only reducing external P loading will take a substantial amount of time, possibly on the order of a decade or more. Parallel reductions in external N loading will speed up the recovery process.

S26-O Effects of filtration timing and pore size on measured nutrient concentrations in natural waters.

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Eutrophication in aquatic systems is caused by excessive nutrient loading. Consequences of eutrophication, such as harmful algal blooms, can be mitigated with legislation and implementation of management thresholds determined using nutrient monitoring data. However, many researchers do not use consistent methods to obtain these data. Many water samples for nutrient analyses are collected using filter pore sizes that allow microorganisms to pass through

the filter and into the sample. Long periods of time may elapse before sample filtering, or samples may not be filtered at all. Microbial processes occurring in samples that are collected this way can alter nutrient concentrations within the sample before analysis. Thus, inconsistent or unsuitable procurement of data can lead to poorly informed management and legislative decisions. Here, 34 freshwater sites in Ohio, Wisconsin, and Florida (USA) were sampled to determine the effects of filter pore size and timing of filtration on measured ammonium (NH_4^+) and orthophosphate (OP) concentrations in water samples. Three filter pore sizes (0.22 µm Nylon, 0.45 µm Nylon, and 0.70 µm glass fiber (GFF)) were used to filter water immediately in the field, after 5 hours in a bottle, and after 22 hours in a bottle. Concentrations of both NH_4^+ and OP varied significantly relative to measurements from 0.22 µm, field-filtered samples (baseline), both over time and with different filter pore sizes. Temporally, samples filtered after 22 hours showed the largest measured concentration ranges, with variances of up to 1000% above and below the baseline. Samples filtered in the field with 0.70 µm GFF filters exhibited over 4000% change versus the baseline. Filtering water samples with a 0.22 or 0.45 µm filter immediately in the field should be adopted as standard sampling practice, and large-scale implementation of standard methods will ensure that reported data represents the best-estimate of actual nutrient concentrations.

S26-O Allelopathic effects of cyanobacteria independent of microcystin-producing trait can be regulated by temperature.

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Cyanobacteria are always reported to suppress other phytoplankton populations by releasing allelochemicals in eutrophic lakes. However, whether their allelopathic effects depends on their genetic characteristics, microcystin-producing trait and environmental conditions is not clear. To explore whether the allelopathic effects of cyanobacteria on green algae depend on cyanobacterial strains and temperature, we investigated the effects of *Microcystis* on the growth of *Scenedesmus quadricauda*. *S. quadricauda* was grown in exudates of a microcystin-producing strain (MC-Ma, FACHB-905) and a microcystin-free strain (MC-free Ma, FACHB-469) of *M. aeruginosa*, and a microcystin-producing strain (MC-Mw, FACHB-905) and a microcystin-free strain (MC-free Mw, FACHB-469) of *M. wesenbergii*, respectively, under different temperature condition. A co-culture system of each *Microcystis* strain and *S. quadricauda* was also designed to test the inhibition of different *Microcystis* strains on the green alga in response to temperature. The results showed that inhibition of *M. aeruginosa* exudates on *S. quadricauda* was significantly stronger than that of *M. wesenbergii* at the optimum temperature, 25 ºC. Inhibition of both MC-free Ma and Mw on the green alga were significantly stronger than those of the MC-producing strains at 25ºC. Lower temperature (25 ºC) decreased the inhibitory effects of the MC-free Ma and MC-free Mw on *S. quadricauda* but increased those of the MC-producing strains. Higher temperature (30 ºC) led to stronger inhibition of *M. wesenbergii* on *S. quadricauda* than *M. aeruginosa*. In the co-culture system, *M. wesenbergii* had more superiority in the competition with *S. quadricauda* than *M. aeruginosa* at 25 ºC. However, *M. aeruginosa* showed stronger inhibition on *S. quadricauda* than *M. wesenbergii* at 20 ºC. *M. wesenbergii* co-cultured with *S. quadricauda* had similar effect as their exudates did at 30 ºC. We therefore conclude that there is no certain correlation between the inhibitory effect of *Microcystis* strains and their abilities to produce microcystin. Their allelopathic effects on *S. quadricauda* is temperature-dependent.

26-P Eutrophication and climate change reduce lacustrine water transparency via increases in organic content and/or phytoplankton biomass.

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Water transparency (Secchi disk depth, SDD), a key physical feature of lake ecosystems, is directly controlled by four optically active substances, of which organics (concentration and composition) and phytoplankton (biomass) are closely related to eutrophication and climate change. However, the mechanism underlying the response of SDD to eutrophication and climate change, especially their combination, is unclear. Here, we examined the SDD variation trends and driving mechanisms based on short-term (35 lakes, July–September 2017) and long-term (3 lakes, 1982–2016) datasets covering lakes with different trophic states on the Yunnan Plateau. In the short-term dataset, increases in organics and phytoplankton occurred with increases in the trophic state and reduced the SDd. In the long-term dataset, the annual air temperature and trophic states increased, and the SDD decreased significantly for all lakes. Significant increases occurred in phytoplankton in eutrophic Lake Dianchi, both phytoplankton and organics in mesotrophic Lake Erhai, and organics in oligotrophic Lake Fuxianhu over time. Furthermore, increases in organics and/or phytoplankton in response to increasing trophic state and climate warming and the combination of these two processes, reduced SDd. The impacts of increased trophic state and its interaction with climate warming are significant, strongest and weakest in the eutrophic, mesotrophic and oligotrophic lake respectively. Additionally, partial impacts of inorganic suspended matter and changes in wind speed and precipitation were observed. Therefore, we conclude that eutrophication and climate change (warming) and their interaction reduced SDD by increasing the abundance of organics and/or phytoplankton, but the effects depended on the lacustrine trophic state.

S26-P Profound changes in the physical environment of Lake Taihu from 25 years of long-term observations: implications for algal bloom outbreaks and aquatic macrophytes loss.

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The global environment has experienced rapid changes over the past three decades, including global warming, global dimming and brightening, and abnormal climate fluctuations. However, direct evidence of global change in the regional physical environment of a lake is rare especially in China because long-term observations are lacking. Here, we demonstrate the profound changes in the physical environment of Lake Taihu using 25 years of long-term meteorological, hydrological and limnological observations and elucidate the potential implications for algal bloom outbreaks and aquatic macrophytes loss. We document significant increasing rates of 0.36 °C/decade and 0.37 °C/decade for the yearly mean air and water temperatures, respectively. In addition, significant increases are observed for the yearly total sunshine duration and yearly

mean water level with the rates of 165.0 h/decade and 0.15 m/decade. In contrast, significant decreases are documented for the yearly mean wind speed and Secchi disk depth with the rates of 0.27 m/(s·decade) and 0.21 m/decade for the macrophyte-dominated regions, respectively. Therefore, the significant increasing ratio of temperature to wind promoted algal bloom formation and outbreaks, while the decreasing ratio of Secchi disk depth to water level resulted in the loss of aquatic macrophytes, which accelerated the shift from a clear macrophyte-dominated state to a turbid phytoplankton-dominated state in Lake Taihu. Forecasts of increased climatic variability in the future pose serious ramifications for both the ecosystem diversity and service functions of large shallow lakes. Our findings highlight the importance of long-term physical environment monitoring data for understanding ecosystem response to global climate change.

S26-P Dynamic variation and impact factors of atmospheric nitrogen and phosphorus deposition in Lake Taihu.

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Due to the impacts of climate change and human activities, atmospheric nitrogen and phosphorus deposition's episodic nature can enhance primary productivity within a short period contributes significantly to the lake eutrophication. In order to clarify the dynamic variation and impact factors of atmospheric nitrogen and phosphorus deposition in typical lake ecosystem of Yangtze River Plain, wet and dry deposition of nitrogen and phosphorus were studied from September 2013 to August 2014 in Taihu Lake station. The acidity of wet deposition enhanced first and then weakened, and acid rain pollution became increasingly serious. The average concentration of nitrogen and phosphorus in wet deposition showed a peak in spring and a valley in autumn, the fluxs of nitrogen and phosphorus deposition decreased slightly compared with that of four years ago, and existed regional differences. The east southeast, east northeast, and northwest wind, which were easily to occorr throughout the year, affected the deposition processes of nitrogen and phosphorus in summer, autumn, and winter, respectively. The correlation analysis between monthly fluxes of nitrogen and phosphorus deposition and meteorological parameters indicated that the nitrogen and phosphorus deposition tended to occur on cloudy and rainy days with low pressure and heavy fog, and high temperature provided the condition for phosphorus deposition. The concentration of nitrogen and phosphorus in wet deposition in spring showed short-term synchronization with slight fluctuation of air quality, while the response of hysteresis in violent fluctuation was more sensitive to the concentration of phosphorus in wet deposition.

S29. Trait-based approaches in aquatic research and management under multiple environmental stressors

S29-O Incorporating trait and metacommunity theory into lake research under multiple stressors.

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Using metacommunity theory to understand the mechanisms that shape organismal community structure is a promising framework that has been widely applied to ecological research. In lakes, the spatial pattern of phytoplankton assemblages depends on the relative importance of environmental filtering (i.e., species-sorting), spatial process (i.e., mass-effect), and grazing

pressure (i.e., bio-interaction), but the inclusion of the latter two factors was often overlooked. We combined trait and metacommunity framework to tease apart important factors shaping phytoplankton community in a Chinese shallow lake. Our results indicated that the taxonomic composition of phytoplankton assemblages is mainly determined by environmental factors (7.6±1.3%), followed by spatial processes (4.7±1.0%) and grazing pressure (2.9±0.5%). However, for the nine species traits groups, the relative influences of environmental, grazing and spatial factors were trait dependent, suggesting that different mechanisms were responsible for the community underscoring the potential advantages of traits in water quality assessment. Furthermore, our results indicated that some traits, e.g., large cell size and filamentous growth form, which are predominantly driven by environmental factors, could be excellent candidates as bio-indicators. In general, our findings suggest that combination of metacommunity theory and the use of traits provide a useful framework for assessing the mechanisms underlying metacommunity patterns in lakes. Nevertheless, further investigations at multi-spatial and temporal scales and development of more effective bioassessment e.g., trait-based indices are greatly needed.

S29-O Effects of environmental factors on taste and odor compound production.

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Taste and odor compounds, such as geosmin and 2-methylisoborneol (MIB), are secondary metabolites that cause drinking water to have an earthy or musty taste and odor. Geosmin and MIB can be detected in minute concentrations (10 ng/L for MIB and 30 ng/L for geosmin) in drinking water and farmed fish, often leading to consumer distrust. Cyanobacteria and actinobacteria are considered the primary producers of taste and odor compounds in freshwater environments, and while geosmin and MIB pose no threat to human health some cyanobacteria are capable of producing toxins that can poison drinking water. Removal of MIB and geosmin is costly and generally unreliable, therefore it is imperative for water resource managers to understand the causes of these events to minimize taste and odor production at the watershed level. Our research focuses on the individual and combined effects of temperature, light, and carbon source on the growth and production of taste and odor compounds by five cyanobacteria and six actinobacteria species. The different taxa included in the study will allow us to investigate interspecific variation in the production of these compounds under variable physiochemical conditions. Studies investigating the effects of environmental stressors on geosmin and MIB production can be valuable for improved forecasting and the prevention of taste and odor events in freshwater drinking water sources and aquaculture production ponds.

S29-O Using trait-based approach to measure the impact of water level change in zooplankton community structure of a sub-lake around Lake Poyang, China.

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Shallow lakes are important for the maintenance of Lake Poyang ecosystem integrity, and

zooplankton play an important role in its substance and energy flow. We investigated zooplankton in all seasons from 2012 to 2016 in a sub-lake of Lake Poyang. The study aims to understand their seasonal dynamics and interannual variation of zooplankton community in relation to environmental variables and water level fluctuations. A total of 115 species were identified in all samples of the 4 years, comprising 87 Rotifera, 13 Cladocera and 15 Copepoda. Rotifera was the dominant group in quantity and its species richness showed a significant seasonal difference (P<0.05 by ANOVA). Furthermore, both density and biomass of zooplankton showed significant seasonal differences (P<0.05). Generally, the density of rotifers was significantly higher, but the density of crustaceans was significantly lower in summer of the high water level years. The result was exactly the opposite in low water level years. However, the density of rotifers and crustaceans decreased significantly in autumn of low water level years, but the density of zooplankton increased significantly in autumn of high water level years. During the flood season, the density of *Bosmina longirostris*, a dominant species, decreased rapidly with the water level increasing. However, its body surface area rapidly increased. Biodiversity indices e.g., Shannon-Wiener index and evenness were dramatically lower in spring than in other seasons. Multidimensional scaling (MDS) analysis suggested that the zooplankton communities can be divided into three groups: spring community, summer–autumn community and winter community associated with distinct indicator species. The results of species richness and community analysis showed that the seasonal succession of zooplankton communities did not have interannual reproducibility. Redundancy analysis revealed that water temperature (WT), conductivity, pH and dissolved oxygen (DO) had significant effects on the zooplankton community. In addition, water level fluctuations, disturbance by wintering waterbirds and artificial water level control during dry season have potential effects on zooplankton community structure too. This study is helpful to further understand the ecosystem stability of lake connected with rivers and provide scientific guidance for lake wetland protection.

S29-O Linking life-history traits to extinction risk of freshwater megafauna.

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Freshwater megafauna, i.e. freshwater animals which could grow over 30 kg, are thought to be more susceptible to extinction due to their intrinsic traits (e.g. large body size and habitat requirement, slow reproduction rates) and external threats including overexploitation, habitat degradation, dam construction and pollution. Though relationships between life-history traits and extinction risk have been examined in several groups such as terrestrial mammals, birds and freshwater fishes, the traits which make freshwater megafauna more prone to extinction have not yet been studied in detail. Given that more than 50% of the assessed freshwater megafauna species are considered threatened on International Union for Conservation of Nature Red List of Threatened Species (hereafter IUCN Red List), such knowledge is needed to help identify target species and areas for proactive conservation planning. We collected trait data (e.g. maximum body mass, longevity, age of maturity, habitat type and feeding habit) for 207 freshwater megafauna species and calculated the average human threat (i.e. Incident Biodiversity Threat Index) within each species distribution range. We used generalized linear mixed models to examine which combination of traits could best explain the conservation status (i.e. IUCN Red List status) of global freshwater megafauna. In a second step, we added human threat data into trait-based models to explore whether human impacts influence the relationships between life-history traits and conservation status. We used the best model based on Akaike Information Criterion to predict

the conservation status of 52 freshwater megafauna species with insufficient information for IUCN Red List assessment (i.e. species categorized as Data Deficient and Not Evaluated). Finally, we discuss the need of monitoring and conservation actions for freshwater megafauna, especially for species with insufficient information but a potential threat status.

S29-O Research on methane emission and microbial community of subalpine peat wetland in Dajiuhu, Shennongjia.

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The changes of the global climate system became a reality. Global warming caused by a sharp increase in the concentration of greenhouse gases in the atmosphere had brought about a series of reactions. Although the concentration of CH_4 in the atmosphere is much lower than that of CO_2, the growth rate of CH_4 concentration in the atmosphere has increased significantly in recent years and due to the strong infrared absorption capacity of CH_4, its global warming potential (GWP) on the century-scale is 25 times higher than of CO_2. Small changes in the concentration of CH_4 in the air can affect the climate. Natural wetlands are the largest source of methane emission; therefore the methane emission flux of wetland ecosystems has become one of the research hotspots. This study takes the sub-alpine peat wetland ecosystem of Dajiuhu, Shennongjia, Hubei Province as the research area. The methane (CH_4) emission fluxes were observed from March 2016 to February 2018 by using the Eddy-covariance method, to explore the process of CH_4 emission flux. The microbial community composition in peat wetland soil was determined by high-throughput sequencing technology, and the correlation between CH_4 flux emission and microbial community composition was studied preliminarily. The main conclusions were as follows:

（1）The results shows that the peat wetland of Dajiuhu is methane source. The daily average release rate (F_d) was 15.57 $nmol \cdot m^{-2} \cdot s^{-1}$, the average daily of CH_4 emission was 15.25 $mg \cdot m^{-2}$ and annual CH_4 budget was 5566.27 $mg \cdot m^{-2}$ in 2016, The daily average release rate (F_d) was 20.36 $nmol \cdot m^{-2} \cdot s^{-1}$, the average daily of CH_4 emission was 28.26 $mg \cdot m^{-2}$ and annual CH_4 budget was 10317.1 $mg \cdot m^{-2}$ in 2017.

（2）The day-night change of methane emission flux during the research period of the Dajiuhu peat wetlands in Shennongjia shows irregularities and the nighttime flux data fluctuated greatly. The changes were more complex than other wetland ecosystems. The average monthly flux of CH_4 in the study area during the two years was mainly emission-based (717 days), the intermittent absorption occurred during 14 days.

（3）The monthly variation and seasonal variation of methane emission flux during the research period changed noticeably: The change of the monthly methane emission flux during the two years has clearly inverted "U" type curve. The CH_4 fluxes increase during the spring period with peak during the summer for both 2016 and 2017; later the emissions decreased during the autumn and remain lowest during the winter.

（4）The microbial community richness and diversity were the highest during the summer, and there were significant differences in microbial diversity among different groups. The main microbial communities in the soil are Crenarchaecta, Euryarchaeota, Acidobacteria, Parcubacteria, Actinobacteria, Firmicutes, Elusimicrobia, BRC1, Chloroflexi and NC10. There were significant differences in soil microbial composition between different seasons; During the summer there is a positive correlation between the composition of microbial community and the soil temperature, same as the composition of microbial community and the air temperature while the composition of

microbial community showed strong negative correlations with moisture content; other three seasons showed no significant correlation with the above environmental factors.

（5）There is a positive correlation between the composition of microbial community and the emission flux of methane during the summer and negatively correlated during the winter. Abundance of Parvarchaeota was positively related with methane flux, while abundance of Crenarchaecta showed strong negative correlations with methane flux.

S29-O Characteristics of zooplankton community structure in potamo-lacustrine complex ecosystem of Poyang Lake -- the importance of river-lake connectivity for maintaining zooplankton diversity.

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Zooplankton is very small and sensitive to the water level fluctuation. In this study, we examined the zooplankton community structure in Poyang Lake and its connected waters in different hydrological periods. During the dry season, flooding period and receding period, 28 samples were set up in Poyang Lake and the connecting waters, the water channel between Yangtze River and Poyang Lake, estuaries of the five major rivers flowing into Poyang Lake) to collect the zooplankton and determine the water environmental factors. 126 species of zooplankton were identified, including 83 species of Rotifera, 25 species of Cladocera, and 17 species of Copepoda. One-way analysis of variance (ANOVA) revealed that species richness of zooplankton in the flood season was significantly higher than that in the receding and dry periods (P<0.05). The species richness of zooplankton in the Poyang Lake and estuaries of the rivers were significantly higher than that in the water channel and the Yangtze River (P<0.05). The similarity percentage of zooplankton species in the four waters ranged from 17.95% to 65.85%. The density of zooplankton in the dry season (2.87±0.71 ind./L) was significantly lower than the flooding period (36.96±10.32 ind./L) and the receding period (81.36±32.56 ind./L) (P<0.05). The results of non-metric multidimensional scale analysis showed that zooplankton community structure in different hydrological periods was significantly different. Redundancy analysis showed that there was a significant positive correlation between zooplankton dominant species and water turbidity, chlorophyll-a concentration, dissolved oxygen concentration, pH value and water temperature (P<0.05). The connectivity between rivers and lakes plays an important role in the exchange of zooplankton species. During the flooding period, zooplankton diversity increased significantly due to the zooplankton of five rivers importing into the Poyang Lake.

S29-O Morphological diversity of Aulacoseira granulata and its role as environmental indicators in the Pearl River.

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Aulacoseira granulata, a cosmopolitan diatom, is the predominant species in phytoplankton communities at the middle and lower reaches of the Pearl River, and its contribution to total biomass could be up to 96.8% sometimes. During these years, the ecological characteristics of *A.granulata* and its indicating role to aquatic environment have been focused on by us in the Pearl

River. The results showed that population abundance, morphological parameters of cells and filaments of *A. granulata* were very sensitive to the changes of aquatic environmental. The relationship between morphological parameters was strong, especially between cell morphological parameters. However, the relationship between cells and filaments was vulnerable to water fluctuations associated with runoff. This probably reflects the interaction between life cycle and size selection. In addition, the phase data from wavelet analysis illustrated that cell diameter was the most sensitive parameter for environmental changes, triggering a common change in cell and filament size, which led to the correlation between cell and algae chain size changes. By comparing self-organizing maps (SOM) of the quality parameters of morphological features with those of quantitative parameters, it was found that the quality parameters generally showed spatial pattern. The percentage of curved filaments was a good bioindicator of spatial patterns because it varied along the nutrient gradient. Furthermore, the percentage of filaments with ending separation spines was a good bioindicator of seasonal variation. Although the quantitative parameters exhibited a clear temporal pattern, no single parameter could be used as a bioindicator of either spatial or temporal patterns. The link between qualitative and quantitative parameters reflected the internal adaptation mechanism of filamentous diatoms to the external environment.

S29-O How does climate model variability cascade into predictions of macroinvertebrate abundance and functional trait composition?

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Climate-change-induced flow alterations are anticipated to affect abundances of species and functional trait composition of stream macroinvertebrates. We modelled flow alterations and its variability for 2050 (2046–2065), and assessed how species abundances and functional trait composition might be impacted. We used two central European river catchments as study areas, each showing distinct hydromorphological characteristics (Kinzig in the central highlands with134 species, and Treene in the central plains with 60 species). Potential ecological effects of changes in species abundances were assessed according to regular monitoring results as required by the European Water Framework Directive. We then tested how the potential variability of flow alterations derived from 16 regional climate models would cascade into the ecological models, and influence the variability in projected abundances of individual species.

Our results showed that the projected flow alterations in the central highlands are likely to affect species abundances depending on the climate model. Variability in the projected species abundances in the central highlands was higher compared to the central plains, resulting in a significantly larger mean of relative changes in species abundances across the 16 climate models in the central plains. Flow alterations had contradicting effects on the overall functional trait composition.

The results of this study provide a quantitative description of abundance changes of individual species due to flow alterations under a variety of climate models, which is valuable for predicting potential impacts of climate change on taxa distributions.

S29-O Elevational variations of leaf N and P relate to species distribution along lakeshore meadow.

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Background: As the limiting factors to plant growth, N and P could mediate species responses to environmental gradients. However, it is not clear how plant N and P content affect species distribution along an elevation gradient. Do nutrients mediate the distribution of species along an

elevation gradient?
Methods: We investigated responses of leaf N and P content to an elevation gradient in Poyang Lake, China, where annual flooding duration decreased from 185 days to 142 days along the elevation gradient during periods.
Results:
(1) Leaf N and P content and N:P ratios showed species-specific responses to the elevation gradient, either positive, negative or non-significant responses.
(2) We observed that soil fertility did not impact leaf N and P content, but nutrient absorption, as a function of flooding, and nutrient use efficiency were important regulators of leaf N and P content, and their influence varied among species, and the significance of these drivers differed among different species.
(3) Leaf P content negatively correlated with species' optimum elevation of distribution, while slope of leaf N-elevation and P- elevation relationship positively correlated with species' elevation range of distribution.
Conclusions: Our study clearly demonstrated that elevation is a primary driver of leaf N and P content. Furthermore, the effect of elevation and flooding on leaf nutrient content is mediated by multiple processes, including physiological responses, such as changes in nutrient absorption and nutrient use efficiency, as well as environmental filters that select for species with different growth rates and nutrient requirements. Thus, flooding has both intra- and inter-species effects on leaf nutrient content along this elevation gradient.

S29-P Long-term changes in the mean traits of the phytoplankton community in Lake Constance.

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The main questions addressed in our study are, how mean traits of the phytoplankton community change with eutrophication and oligotrophication and whether changes in the values of mean community traits are related to the community dynamics. The study is based on the long-term data set on phytoplankton in Lake Constance covering the period 1965 – 2007 (43 study years) with 1040 sampling dates. Each phytoplankton species was associated with trait values for the traits cell volume, maximum growth rate, grazing resistance, phosphate affinity and alpha, i.e. the initial slope of the growth-irradiance curve based on published trait compilations (Bruggeman 2011, Schwaderer et al. (2011). In cases in which trait values were not available they were estimated based on phylogenetic relationships. Annual averages of mean community trait values were calculated from the species traits and the biovolumes of the species at a given time. These mean community traits are sensitive to the trophic state of the lake. The long-term changes in the trait values are mainly due to changes in the relative abundance of the major phytoplankton groups rather than to changes of the species composition within these groups