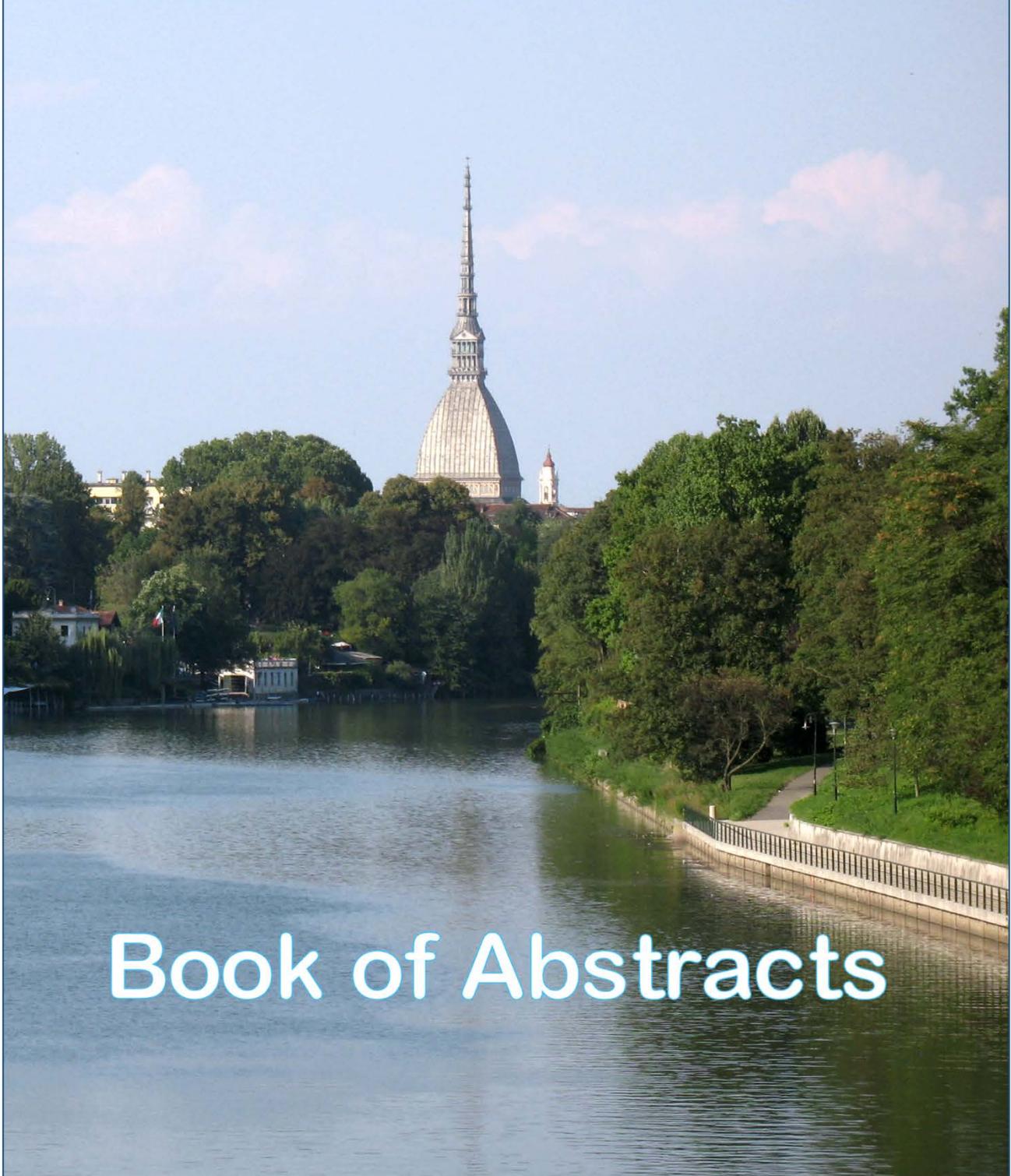# SIL 2016
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PLENARY LECTURES

KICK-OFF LECTURE: **Water management in Theban archaeology.** *Christian Greco*

Director of the Foundation Museum of Egyptian Antiquities in Torino

After the construction of the Aswan Dam and the consequent formation of Lake Nasser, the hydrogeological system of Egypt has completely changed. There has been a rise of the water table, aggravated by intensive cultivation of sugar cane, which requires constant irrigation. Moreover, the sandstone temples are suffering a lot. To save time, major dewatering projects were launched, which involved placing pumps inside trenches to bring down the water level. This temporary solution has had a huge impact on an area that has one of the highest archaeological densities in the world. The issue of the sustainability and preservation of the local archaeological heritage has now become extremely urgent. Addressing it will necessarily require a synergy with other disciplines and, above all, a rethinking of agricultural policies.

BALDI MEMORIAL LECTURE: **Coaxing lakes to conduct experiments: palaeolimnology and the acid rain debate.** *Richard W Battarbee*

Environmental Change Research Centre, University College London, UK

In the 1960s the occurrence of unusual algal blooms on large lakes throughout the world alerted limnologists to the new phenomenon of cultural eutrophication. Unfortunately at that time the young strand of limnology we call "palaeolimnology" was not ready to make a meaningful contribution to the debate that followed when the "when" and "why" questions were posed by worried drinking-water supply companies and other lake-water users. However, a decade or so later when surface water acidification problems were detected in low alkalinity lakes the situation had changed; palaeolimnology had come of age. Most crucially with the emergence of ^{210}Pb dating it was possible to date recently accumulated sediments in lake basins enabling diatom analysis in particular to become a powerful diagnostic technique. And by comparing the palaeoecological records of lakes of different kinds, with different bedrock geology, different catchment land-cover and different acid deposition inventories it was also possible in the words of Ed Deevey "to coax history to conduct experiments" (Deevey, 1969). This approach was apposite as the primary hypotheses put forward to explain the loss of salmonid fish populations in highly acidic surface waters in the UK and Scandinavia (i.e. acid deposition, land-use change and natural leaching) all demanded a demonstration, if not an understanding, of processes playing out over long time-scales, well beyond the reach of the observational record. For instance, acid deposition became an important driver of change in upland lakes in the UK already by the mid-nineteenth century, land-use change in Norway that led to the regrowth of spruce forest began to occur in the later decades of the 19th century and a test of the natural leaching hypothesis required centennial to millennial scale evidence.
Following a series of large, multi-institutional and multi-national palaeolimnology projects during the 1980s in Europe and North America the primacy of the acid deposition hypothesis was established (e.g. Battarbee, 1990; Charles, 1990). Subsequent measures to reduce the emissions of acidic gases from the combustion of fossil fuels have led to a marked reduction in acid deposition and, judging from long-term monitoring data, the gradual recovery of acidified lakes and streams is now taking place (Curtis et al., 2014). However, when today's diatom assemblages are compared to those found in early 19th century sediments that pre-date the acidification phase it is clear that the recovery process has a long way to go (Battarbee et al., 2014). And as climate change now threatens to exert increasing pressure on ecosystem processes the path back to good ecological status may well be further confounded. A new experiment is unfolding in which the lake sediment record continues to perform a historical benchmarking role as potentially new ecosystems are being created. How such ecosystems should be managed is an open question (cf. Murcia et al., 2014).

KILHAM MEMORIAL LECTURE: **Ecological isolation despite physical connectedness: evolution-dependent species richness in large and deep lakes.** *Ole Seehausen*

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The relationship between species richness and ecosystem size remains incompletely characterized for lakes. Some of the large lakes of the world have a long history of investigation as hotspots of endemic species diversity, but other large

lakes are very poor in species, and the richness of the former is confined to a handful of taxa. I will try to reconcile these observations, specifically working with fish communities.

We have studied the relationship between richness, physical properties of lakes and species traits for assemblages of cichlid fish across more than 40 African lakes. In this data set we observed that lake surface area and lake depth best predicted species richness. Surprisingly, lake age had no effect at all. When we partitioned species diversity into a component that was locally evolved and an immigration component, it emerged that the process of intralacustrine speciation increased the slope of the species-area relationship from z = 0.132 to z = 0.250 leading to more species per area by an order of magnitude (Wagner et al. 2014). From these observations one may conclude that assembly by immigration alone is insufficient to generate saturated lacustrine communities, and that species richness is additionally constrained by lack of speciation within lakes. In the same data set we observed that the depth of lakes and the presence of species traits that facilitate speciation were strong predictors of whether speciation happens. Speciation requires deep lakes and rapidly evolving mating systems (Wagner et al. 2012). When both are given and cichlids radiate, they diversify into successively greater water depth with successive speciation events and they eventually fill the entire oxygenated habitat of the lake (Seehausen 2015). When cichlids do not radiate, they remain confined to a limited sector of the lake, mostly shallow littoral habitat. Contrary to common thinking, cichlids did not require isolated lakes to radiate. Up to 50 other fish species have colonized the larger of the African Great lakes, but with a few exceptions, all of them remained confined to shallow littoral habitats and only very few speciated within the lakes. The bulk of the fish biomass in deep and offshore waters are most often cichlid fish.

More recently we started uncovering similar speciation patterns and species-area relationships for fish in the archipelago of European pre- and subalpine lakes. Several lineages of salmonid fish have made intralacustrine radiations, and these radiations can fill the major physical habitats of the lakes, but where they did not radiate (or their radiation was lost due to anthropogenic impact), their single populations tend to be confined to shallow sectors of the lakes (Vonlanthen et al. 2012). Like in African lakes, many other fish species have colonized these lakes too, 30 or more in the larger lakes. Yet, very few are able to colonize deep water and pelagic habitat.

Lakes are often likened to oceanic islands as being physically isolated from rich "continental" species pools. However, the more appropriate concept for lakes may be one of ecological isolation rather than physical isolation. Lakes that harbour large endemic radiations tend to be well-connected to river networks and harbour a rich diversity of non-endemic fish that colonized from the rivers. However, most of these lack the adaptations required for survival and reproduction in profundal and pelagic lacustrine habitats. Hence, the resources in these habitats are accessible only to a very small subset of the colonizing species. For fish to utilize the richness of lacustrine resources, endemic diversity has to evolve in every case from these colonists through the process of adaptive radiation.

PLENARY LECTURE: **Climate change and stoichiometric implications for zooplankton.** *Esteban Balseiro*

Laboratorio de Limnología, INIBIOMA, CONICET-UNComahue, Bariloche, Argentina.

Global change is affecting aquatic systems in many ways, through temperature increase, changes in transparency, irradiation and nutrient loads, affecting ecosystem stoichiometry, and so organismic fitness. Due to temperature increase, glaciers around the globe are melting rapidly, threatening the receiving environments of the world's fresh water reservoirs with significant changes. The meltwater, carried by rivers, contains large amounts of suspended sediment particles, affecting downstream lakes. These suspended particles modify lake transparency depending if the suspended material tends to increase or decrease according to glacier recession. Changes in underwater photosynthetically active radiation would affect food quality for zooplankton by changes the light-nutrient ratio in the water column. In addition, changes in water transparency also affects URV penetration, and hence the oxidative stress generated by these light wavelengths. Here we analysed how food quality, in terms of elemental ratios, interact with factors as UVR and oxidative stress. In a first step, through laboratory and field experiments, we analysed how food quality affects the capacity of zooplankters (*Daphnia* and calanoid copepods) to respond to UVR generated oxidative stress. Then we moved to field studies to evaluate these results in natural zooplankton populations. Lake Mascardi, located in the North-Patagonian Andean lake district, is a deep ultra-oligotrophic lake that receives the Upper Manso River, which begins at the largest glacier of Tronador Mountain (3554 m a.s.l.). Glacier fluctuations on Mountain Tronador have been observed since 1976 and show a continuous recession. We took advantage of a 10 km light gradient in Lake Mascardi, analysing interannual variations in water transparency, UVR penetration and food quality as interacting factors affecting zooplankton populations. Along this transparency gradient we found significant differences in light:nutrient ratio and stoichiometric food quality of the seston, together with a switch from dominance of P-rich *Daphnia* in low carbon:nutrient stations to the dominance of low-P copepods in high carbon:nutrient stations. In

addition, we analysed the oxidative stress due to UVR in *Daphnia commutata* and how this factor can modulate the coexistence with other potential competitors such as the copepod *Boeckella gracilipes*. In summary, here we showed how climate change would affect zooplankton via changes in food quality and UVR effect.

PLENARY LECTURE: **Biodiversity and ecosystem functioning in miniature worlds.**   *Thomas Bell*

Imperial College London, Faculty of Natural Sciences, Department of Life Sciences (Silwood Park), Buckhurst Road, Ascot, Berkshire, United Kingdom

Abstract. Bacteria drive many functionally important processes in aquatic ecosystems. Nonetheless, the bacterial component of aquatic ecosystems is often treated as a "black box" with neither a complete understanding of how bacterial communities are structured, nor of how changes to the composition of bacterial communities influence ecosystem functioning, nor whether such compositional changes influence the ecology of larger organisms. The talk will describe experimental approaches we have used for opening the black box to understand linkages between bacterial community structure and function, focusing on understanding how interactions among bacterial taxa can be measured, how interactions evolve, and how interactions can be manipulated in the lab or in nature. We find that interactions among bacterial taxa are dynamic over ecological and evolutionary timescales. For example, during ecological succession, strong interactions are dampened to become more neutral. Over evolutionary timescales, the types of interactions that emerge depend on the composition and diversity of the surrounding community. I will discuss experimental approaches to extrapolate these findings from the lab to the field.

PLENARY LECTURE: **Challenges and opportunities for research and management in Mediterranean-climate rivers.**   *Núria Bonada*

Department of Ecology, University of Barcelona, Spain

Rivers in Mediterranean climates (med-rivers) are unique ecosystems because of their predictable winter flooding and summer drought regimes. These characteristics are key drivers of aquatic and riparian organisms, and the ecosystem functions and services they provide. Med-rivers are hotspots of biodiversity, supporting species adapted to both floods and droughts or using them for part of their life histories. At the same time, flow seasonality drives fluxes of nutrients and organic matter and, consequently, food web dynamics. Med-rivers have been affected for centuries, in some cases millennia, by multiple human activities that increasingly threaten these ecosystems worldwide. These threats include changes in land use, nutrient loads, heavy metal concentrations, salinity, water withdrawals, invasive species and, more recently, xenobiotics or emerging organic pollutants. In addition, future climate change scenarios predict increases in drought conditions and in the occurrence of extreme events, such as floods, heat waves, and wildfires. The diversity of aquatic organisms is declining more rapidly in med-rivers than in rivers anywhere else in the world and, for some taxonomic groups, Mediterranean regions have more introduced than native species. River management in med-rivers requires innovative approaches to account for both natural and human disturbances. Most research conducted in med-rivers has focused on the effects of flow seasonality and human pressures on biodiversity and ecosystem processes; however, there is a still large gap in linking basic and applied research knowledge to improve bioassessment, conservation, and restoration practices. Little ecological and biological information is also available in several Mediterranean regions, and consequently these regions are being slow on implementing sustainable river management policies and species conservation programs.

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PLENARY LECTURE: **Limnology in the 21st century: Incorporating data-intensive research, open science, and team science to address broad-scale problems.**   *Kendra Spence Cheruvelil*

Lyman Briggs College & Department of Fisheries and Wildlife, Michigan State University, U.S.A.

Human-induced global stressors, such as global climate change, land use intensification, and the spread of invasive species, are emerging as the greatest environmental challenges of the 21st century. These stressors are having and will have significant consequences for aquatic resources, ecosystem and human health, and the economy. Knowledge gained from studying single systems intensively will not provide all of the solutions needed to understand these broad-scale and complex problems. Therefore, new perspectives and approaches are needed to help meet such challenges. This plenary will provide examples of the ways that three emerging strategies are likely critical for helping aquatic science meet broad-scale environmental challenges—data-intensive research, open science, and team science. I will highlight data-intensive research about lakes and their major nutrients, which are affected by many human and natural drivers that operate and interact across scales of time and space. My collaborators and I compiled and harmonized data from ~8,000 lakes in 17 U.S. states spanning 1,600,000 km2 and 30 years into a multi-scaled geospatial lake and landscape database. We use data-intensive tools from statistics and computer science (e.g., Bayesian multi-level modeling, data mining, machine learning) in an science framework in which we publish and make available our datasets, code, and tools. As limnology's quantitative methods change, so too must our cultures and practices. In fact, data-intensive approaches are best served by large, interdisciplinary teams. Therefore, I will also present examples of how we have used team science to create, train, and assess our interdisciplinary research teams to function to their fullest potential. Ultimately, such data-intensive and team-based research will inform freshwater management and policy by providing ways to incorporate lake-specific knowledge and understanding into continental and global-scale freshwater solutions.

PLENARY LECTURE: **Histories of cyanobacteria from a northern country: redefining limnological "nordicity".**   *Frances Pick*

Faculty of Science, Biology, University of Ottawa, Canada

Increased nutrient loading and warmer waters are thought to be the main reasons cyanobacterial blooms have become more frequent and intense in temperate lakes. Of particular concern is the potential increase in toxic cyanobacteria because of their impacts on wildlife and human health. Over the past few decades, substantial warming in Northern Canada and the Arctic has been reported, along with sporadic reports of cyanobacterial blooms in lakes further north than previously found. Overall the North is considered highly sensitive to climate change, yet there is little limnological monitoring of any of the hundreds of thousands of lakes in this vast region. Given the present warming trend, we predicted that the sediment record in northern lakes would show a concomitant rise in cyanobacteria, perhaps even in the absence of changes in trophic state. To test this hypothesis we conducted a small survey of lakes along a latitudinal gradient from the sub-Arctic to Arctic Canada. Using a top/bottom approach to analyze sediment cores, we extracted and analyzed cyanobacterial DNA abundance (by quantifying copy numbers of cyanobacterial 16S rRNA genes) and composition (high throughput sequencing). Along with more detailed sediment DNA analyses through time of dated cores from oligotrophic Great Slave Lake (~ lat. 60° N and the tenth largest lake in the world), we found an overall trend of more cyanobacteria at the top of cores as well as shifts towards planktonic bloom-forming and potentially toxic genera coupled with decreases in diversity at some sites. Some northern lakes have also experienced an increase in toxin genes (for the hepatotoxic microcystins). Sediment DNA combined with more traditional proxies of lake histories are redefining our understanding of northern limnology. These results and empirical models linking cyanobacterial biomass to surface water temperatures provide an additional argument for global action on reducing anthropogenic carbon dioxide emissions.
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PLENARY LECTURE (winner of SIL Student competition): **Climate change and multiple stressors in agricultural streams.**   *Jeremy (Jay) Piggott*

University of Otago, New Zealand

Climate change and its impacts are likely to be the dominant driver of biodiversity loss and changes in ecosystem functioning by the end of this century. But how the various drivers of climate change will interact with the multiple stressors already impacting ecosystems remains the largest uncertainty in projections of future biodiversity change. My research seeks to understand how climate and land-use related stressors interact to affect biodiversity and ecosystem function in freshwaters. In particular, I study how multiple stressors interact to create 'ecological surprises' in the form of complex, non-additive effects such as synergisms (amplified combined effects) or antagonisms (reduced effects). My investigations have studied multiple stressors in streams across a range of spatial scales using multi-factorial manipulative field experiments to disentangle complex interactive effects from genes to ecosystems. This knowledge is essential for effective freshwater management and policy, and to advancing multiple-stressor theory in the face of global change.

02. THE FRESHWATER MICRO EUKARYOTIC WORLD: ROLE AND RELEVANCE FOR THE ECOSYSTEM

02-O   Single spore analysis reveals diversity and host specificity of parasitic fungi infecting phytoplankton.   *Maiko Kagami [1] - Daiki Nozaki [1] - Kensuke Seto [2] - Takaki Nakamura [1] - Christian Wurzbacher [3]*

Faculty of Science, Toho University, Chiba, Japan [1] - Sugadaira Montane Research Center, Tsukuba University, Nagano, Japan [2] - Department of Biological and Environmental Sciences, University of Gothenburg, Gothenburg, Sweden [3]

Parasitic fungi infecting phytoplankton play important roles in controlling phytoplankton blooms and food web dynamics. Yet, the diversity of planktonic fungi remains largely unknown due to the lack of distinctive morphological features and methodological limitation. In this study, a genomic single-spore method was applied to identify each fungal sporangium attached to host phytoplankton species in lakes. With this molecular tool, we examined the seasonal changes in the prevalence of infection, abundance and species composition of parasitic fungi and host, and host specificity of each fungus in Lake Inba. Our results showed that parasitic fungi infecting dominant diatoms (*Aulacoseira granulata*, *A. ambigua*) were affiliated not only to Chytridiomycota (chytrids), but also to Cryptomycota (Rozellomycota). Algal infecting fungi are diverse and some chytrids form novel phylogenetic lineages. During typical chytrid epidemics with over 90% infection rates, host algae population sizes are significantly reduced. However, that is not the case in Lake Inba, where the percentages of infection by chytrids on two dominant diatom species, *A. granulata* and *A. ambigua*, were relative low (<20 %). The abundance of fungi and hosts showed a similar seasonal pattern, while the infection rate stayed rather constant. Low infection in Lake Inba could be due to high growth rates of diatoms in eutrophic lake water. Host specificity depended on the fungal clade, i.e. some were specific to *A. granulata*, while others could infect both host species. Chytrids are often considered to be highly host-specific parasites, our study revealed the extent of host specificity may differ among species and same fungi can infect various host. In addition, both host species were infected by diverse fungi on the same time. The degree of host specificity was also confirmed by cross infection experiments using 5 chytrids and 4 potential host diatoms (*A. granulata*, *A. ambigua*, *Synedra* sp. and *Asterionella formosa*). 2 chytrids could infect all 4 diatoms, while other 3 chytrids can infect only their own host diatoms. Our data suggest that multiple infection by various fungi, and low host specificity of parasitic fungi may have less impact on host dynamics than highly host specific parasites. This is the first study to show that parasitic fungi are very diverse, and host specificity varies between fungal species in the field. Further studies may reveal ecological relationships between diverse fungi and phytoplankton in aquatic ecosystems.

02-O   Chemical interactions between filamentous green algae and diatoms in freshwater phototrophic biofilms - a metabolomic and transcriptomic approach.   *Allen Joey [1] - Roux Christophe [2] - Culioli Gérald [3] - Ten-Hage Loïc [1] - Leflaive Joséphine [1]*

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The chemical inhibition of competitors, *i.e. allelopathy,* is known to influence the structure and dynamics of phytoplanktonic communities. However, this process remains poorly studied in benthic communities. The filamentous green algae *Uronema confervicolum* was previously determined to inhibit diatom adhesion by the release of unidentified chemicals. The aim of this study was to determine:
   (i)   how *U. confervicolum* inhibits diatom adhesion by the determination of the involved compounds,
   (ii)   what is the environmental influence on this inhibition
   (iii)   what are the mechanisms of the process of inhibition of diatom adhesion.
In this respect, the production of allelopathic compounds by the filamentous green algae in several environmental conditions was analysed by metabolomics coupled with bioassays. The various environmental conditions were obtained by a modification of nitrogen and phosphorous concentration in an artificial culture medium and by different light and aeration conditions. The four culture media were: (a) COMBO, (b) COMBO with N depletion (- 20%), (c) COMBO with P depletion (- 40%) and (d) COMBO with N (- 20%) and P (- 40%) depletion. The effect of anti-adhesion allelochemicals on diatoms was studied through transcriptomics, metabolomics, and extracellular polymeric substances (EPS) analyses.

The results showed that the anti-adhesion allelochemicals were produced independently of other allelochemicals that inhibited diatom growth and were linked to carbon assimilation and nutrient availability. The effect of *U. confervicolum* extracts on diatom adhesion was higher in high irradiance conditions (60 µmol m^{-2} s^{-1}). The impact of irradiance and aeration depended on nutrient conditions. The main effect on diatom adhesion was notably linked to a strong inhibition of EPS production.

This study would allow the identification of anti-adhesion compounds and the determination of the mechanism which induced a reduction of diatom adhesion. Unravel such a chemically mediated interaction between these two biological models would be a first step to understand the role of chemical interactions in the shaping of freshwater phototrophic biofilms and mechanisms of diatom adhesion.

02-O   Parasitic oomycetes in freshwater planktonic environments: ecological and evolutionary roles.
Amanda Valois

Department of Zoology, University of Otago, Dunedin, New Zealand

Oomycetes are a diverse group of fungal-like organisms, representing one of the eukaryotic groups which have the greatest impact on human health and ecosystem functioning. In recent years, there has been growing interest in the evolutionary phylogeny of oomycetes and their importance as animal pathogens, particularly the oomycete genera *Aphanomyces*, *Saprolegnia*, and *Pythium*. In freshwater environments, oomycetes have been recorded parasitizing phytoplankton and zooplankton, benthic invertebrates, fish, and other oomycetes species. The distribution and diversity of oomycete parasites just in zooplankton species alone suggests that we are greatly underestimating the ecological role of oomycetes in freshwater communities. In this review, the present knowledge regarding oomycetes as parasites in freshwater planktonic communities is summarized. This includes host use, transmission dynamics, pathology, geographic distribution, and their role in heterotrophic flagellate community composition and energy transfer. Knowledge of oomycete host-parasite dynamics is compared and contrasted to that of chytrid parasites and their phytoplankton hosts. Finally, areas of research requiring particular focus in the future are outlined, particularly for oomycetes and emerging infectious disease. Parasitic oomycetes have a number of important characteristics of emerging infectious diseases, including a wide host range and ability to grow outside their host. A more complete understanding of the diversity, role, and evolution of parasitic oomycetes within freshwater environments will be essential for understanding how this group utilizes different hosts and substrates and contributes to overall ecological functioning in aquatic systems.

02-O   Development of a disturbance index based on high frequency temperature measurements and its test on phytoplankton assemblage equilibrium during summer stratification in Lake Erken. *Yang Yang [1] - Kurt Pettersson [2] - Judit Padisák [3]*

Erken Laboratory, Uppsala University, Uppsala, Sweden [1] - Erken Laboratory, Uppsala University, Norrtälje, Sweden [2] - Department of Limnology & Mta-pe Limnoecology Research Group, University of Pannonia, Veszprém, Hungary [3]

Physical forces, particularly solar radiation and wind speed, constitute major sources of disturbance for aquatic ecosystems. They initiate a chain of reactions affecting temperature, light conditions, nutrient availability and phytoplankton development. Phytoplankton succession in lakes is the outcome of interactions between both internal succession processes and external disturbance. A new disturbance index (DI) based on automated high-frequency temperature measurements was defined to quantify the environment stability and applied to test the phytoplankton equilibrium during summer in Lake Erken. To test the performance of DI, years with short and unstable summer stratification in Lake Erken was compared to years with long and stable summer stratification. Species composition of phytoplankton shifted in response to disturbance during summer stratification, and an equilibrium of phytoplankton could form only when there was a long period of stable environment without strong disturbance. The influence of disturbance on the process towards equilibrium of phytoplankton was associated with the development of thermal stability. The DI developed in this study performed well in indicating the environmental stability and provides a robust and novel method to study disturbance in a stratified freshwater ecosystems.

02-O   Periphytic algal community along a longitudinal gradient: functional convergence or functional divergence? *Nicolli Cristina Osório, Andressa Bichoff Pereira, Bárbara Dunck Oliveira, Daiane Trevisan Ruwer, Liliana Rodrigues*

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River-floodplain systems are important ecosystems in the Neotropical realm, due to their tremendous species diversity. Construction of dams has affected these environments, reducing the hydrological connectivity between rivers and associated plain, reducing nutrient cycling, leading to loss of freshwater habitats and biological communities. Functional diversity is a tool which estimates the differences among organisms directly through their functional characteristics, and this diversity can be driven by environmental filters, limiting similarity or neutral processes. Here, we evaluated the functional diversity of periphytic algae along a longitudinal gradient of a floodplain. We hypothesized that there will be a positive association between functional diversity and the distance from the dam, leading to functional divergence, and that these values will be different than expected by the chance. We expect that the diversity of periphytic algae functional traits of increases with the distance from the dam, regardless of the increase or not in species richness, and this would be a result of deterministic processes (non-neutral process, as the limiting similarity or environmental filters). Samples were taken in 2014 (low water phase) over 230 km of the Upper Paraná River floodplain (Brazil) in 13 sites on the plain and the main river. The periphytic algae were removed from petioles of *Eichhornia azurea* (Sw.) Kunth and quantified by standardized methods. Limnological variables were also sampled in the same locations. We used four functional algae traits (life form, adherence form, adherence intensity, and nitrogen fixation). The functional diversity of each sampling location was measured and compared with the average value of random communities generated by null models. We identified 379 species. The species diversity increased along the longitudinal gradient, but there was no increased in functional diversity. Along the gradient, prostrated species were more representative; there was an increase of stalked and entangled species, whereas the mobiles, with basal cells and mucilage tube, decreased. The results of the null model demonstrated lower values than expected by chance (functional convergence), indicating the influence of limnological variables (environmental filters) on functional diversity. The distance from the dam was not an influential factor of functional diversity, refuting our first prediction. Therefore, during low water phase, each floodplain environment has specific limnological features, which can prompt increased or decreased functional diversity independent on the longitudinal gradient (distance from a dam). Therefore, confirming our second prediction, we conclude that the environmental filters as deterministic processes displayed by local abiotic factors played a major role determining functional convergence in the peryphitic algae of the upper Paraná River and associated plain.

02-O   Long-term infection dynamics of chytrid parasites and their pelagic phytoplankton hosts.
Alena Sonja Gsell [1] - *Berta Ortiz Crespo* [2] - *Sabine Hilt* [2] - *Ellen van Donk* [1] - *Rita Adrian* [2]

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Parasitism has generally been neglected in ecological network research even though recent studies have shown that parasites can add substantial biomass, diversity, previously unrecognized trophic links and complexity to food-webs. In particular, baseline data on the effects of parasites on non-host species in the community is still needed to better understand the direct detrimental and indirect (potentially) beneficial effects of parasites in the food web. Here we use the extant long-term collection of weekly samples of Lake Müggelsee (Germany, 1979-ongoing) to quantify the long-term dynamics of chytrid (fungal) infection of multiple pelagic phytoplankton species. We will use these infection time series to a) test for effects of host density, non-host diversity, predation and environmental conditions (light, temperature, nutrients) on the infection occurrence and prevalence, and b) run multivariate autoregressive models to identify and quantify the direct and indirect interactions of chytrids with producers and consumers in the planktonic interaction-network of a well-studied eutrophic lake.

02-P   Micro-crustacean communities (Crustacea: Ostracoda, Cladocera) from karst aquatic ecosystems of the northern neotropics.   *Norma Fernanda Charqueño-Celis* [1] - *Liseth Carolina Pérez-Alvarado* [2] - *Manuel Elías-Gutiérrez* [3] - *Alexander Corrrea-Metrio* [2] - *Mark Brenner* [4] - *Antje Schwalb* [5] - *Laura Anahi Macario-Gonzalez* [5] - *Sergio Cohuo-Duran* [5] - *Paula Echeverria-Galindo* [1]

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The Neotropical Yucatan Peninsula is a karst environment that possesses a large number of aquatic ecosystems. The most famous water bodies on the peninsula are the open *cenotes*, or solution sinkholes. In the southern part of the region there are several lakes of different origin. Numerous aquatic invertebrates are found on the peninsula, and among the most abundant and diverse are the Ostracoda and Cladocera. We collected and identified ostracodes and cladocerans from surface sediments obtained with an Eckman dredge of 11 aquatic ecosystems in the southern Yucatan Peninsula (Muyil, Señor, Chichancanab, Sijil Noh Ha, Emiliano Zapata, Chacchoben, Miguel Hidalgo, Bacalar, Encantada, Chacanbacab, and San Jose de la Montaña). This study provides basic information about the species richness, relative abundances and spatial distribution of cladocerans and ostracodes that inhabit karst aquatic ecosystems in southeastern Mexico. A total of 1420 individuals were identified, of which ostracodes represented 69.7% and cladocerans 30.3%. Cladocerans, however, displayed higher species richness, with 16 species from 13 genera and five families. Chydoridae was the family with the greatest number of species (8). *Macrothrix elegans* was the most common cladoceran, represented by 164 individuals from nine localities. Ostracoda were represented by 14 species from 13 genera and five families. The family Cyprididae was the most diverse, with five species. *Cypridopsis vidua* was the most abundant taxon, with 447 individuals. Lakes Chacanbacab and Chichancanab showed the highest diversity, with a combined total of 10 microcrustacean species, but Chacanbacab had more species of cladocerans (7) than ostracodes 3. In Lakes Chichancanab and Bacalar, we found a higher number of ostracodes, with 10 species in each. Emiliano Zapata had the greatest overall crustacean abundance, and of 424 individuals, 414 were ostracodes. Chacanbacab was second in terms of total crustacean abundance (244 individuals), but the cladocerans dominated (195). This represents the first time that Chacanbacab, Sijil Noh Ha, Señor and San Jose de la Montaña were studied. All of the crustacean species found have a Neotropical distribution and were reported previously from other aquatic ecosystems in the lowlands of the Yucatan Peninsula. We encountered the ostracode *Darwinula stevensoni* and the cladoceran *Ilyocryptus spinifer*, which are widely distributed in water bodies on the peninsula. Both ostracodes and cladocerans are common invertebrates in the karst aquatic ecosystems of the southern Yucatan Peninsula. In general, they display similar species richness, but ostracodes often outnumber cladocerans, except in Lake Chacanbacab, where the most numerous and diverse microcrustaceans are Cladocera.

02-P　Desmids in a shallow lake, now and in the 1920s. *Tore Lindholm , Ronja Lanndér*

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Timmerträsk in Åland, SW Finland, is a small and shallow forest lake (area 5 hectar, depth <3 meter). Its flora was studied by Carl Cedercreutz in the 1920s, in a survey of more than 120 lakes in Åland (Acta Bot. Fenn. 15:1-120, 1934). He found 141 species of desmids in Timmerträsk, which he considered to be one of the most species-rich lakes in Åland. One or several *Micrasterias* species occurred in 39 lakes. The lakes were revisited in the years 1999-2004 (T. Lindholm). Then *Micrasterias* was found only in 25 lakes, but 14 *Micrasterias* species occurred in Timmerträsk. In a study in July 2015, the same 14 *Micrasterias* species were recorded. *Chara virgata*, *Fontinalis antipyretica*, *Drepanocladus* sp. and *Utricularia vulgaris* were important substrate plants for *Micrasterias*. Cedercreutz (1934) reported only 6 *Micrasterias* species from Timmerträsk, but great numbers of species of the genera *Euastrum*, *Cosmarium*, *Staurastrum* and *Closterium*. Many *Micrasterias* species are rare and even red-listed. As Timmerträsk is relatively undisturbed, has a high biodiversity recorded in the 1920s and still in 2015, it is worth protection.

02-P　Ecological assessment of two karstic lakes (Plitvice lakes NP) using perennial data from phytoplankton and phytobenthic communities. *Petar Žutinić, Buga Berković , Marija Gligora Udovič, Koraljka Kralj Borojević, Anđelka Plenković Moraj*

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According to requirements of the EU Water Framework Directive (WFD) ecological status of Lakes Kozjak and Prošće was assessed using biological quality elements (BQEs) - phytoplankton and phytobenthos, emphasizing diatoms as the main algal group characterizing both communities. Starting from 2009-2010, investigations resulted in designation of descriptor species for each of the two BQEs. For phytoplankton descriptor species were used to establish: 1) ecological quality ratio (EQR) based on Chl a and total phytoplankton biomass, and 2) phytoplankton assemblage index (Q). As for the phytobenthos, descriptor species were used to develop Croatian trophic diatom index (TID$_{RH}$), a mandatory biological tool in evaluating the ecological status of water. The results indicated that Lake Kozjak was characterized by a codon **B** centric *Cyclotella distinguenda* reaching maximum biomass in July (0.03 mg l^{-1}), sharing codominance with group **E** (*Dinobryon divergens/D. sociale/D. cylindricum*), and with several descriptors from coda **D** and **L$_0$** (*Ulnaria ulna* var. *acus* and *Parvodinium inconspicuum/Peridinium cinctum*). The following functional group (FG) succession pattern was noted: **E→(B-E)→(B-D)→B**. The phytobenthic community of Kozjak was characterized by species *Achnanthidium minutissimum*, *Brachysira vitrea* and *Encyonema muelleri*. According to TID$_{RH}$ index (range 1.5-2.3) ecological status of Lake Kozjak was assessed as high. In Lake Prošće codon **C** associated *Stephanodiscus neoastraea* was the most dominant species with a maximum biomass in July (1.69 mg l^{-1}). Codon **B** was also represented in Prošće with the species *Cyclotella distinguenda* Hustedt (max biomass 0.34 mg l^{-1}, in September) and *C. plitvicensis* Hustedt (max biomass 0.14 mg l^{-1}, in June). Apart from the centric diatoms, coda **E**, **P** and **D** were also noted coexisting with species *Dinobryon divergens/D. sociale/D. cylindricum*, *Synedra* sp./*Fragilaria crotonensis* and *Asterionella formosa*, respectively. According to dominant FGs, the following succession was recorded: **(P-C-E-D)→(E-D)→C→(C-E)→C**. The phytobenthic community was characterized by *Achnanthidium minutissimum, Cyclotella meneghiniana, C. plitvicensis, Encyonopsis microcephala, E. minuta, Fragilaria capucina, F. crotonensis, Kobayashiella parasubtilissima* and *Stephanodiscus hantzschii*. The range of TID$_{RH}$ (2.2-2.5) indicated good ecological status of Lake Prošće. The assessments based on the EQR and the Q index indicated high ecological status of both lakes.

The aim of recent ongoing investigation on Plitvice Lakes from 2015-2016 was to assemble perrenial data using the same sampling methodology during the same temporal interval and the same spatial position in order to produce a comparable and significant statistical evaluation of ecological status of the Lakes. Moreover, after the calibration process the aggregated data will be compared and the results will be further discussed in terms of ecological assessment status.

02-P   Long-term dynamics of microbial eukaryotes diversity: paleolimnological view based on HTS of sedimentary DNA. *Isabelle Domaizon*

INRA, CARRTEL, Thonon les Bains, France

The application of novel high-throughput sequencing technologies have recently revealed a very high diversity within the planktonic assemblages. Understanding the dynamics and distribution of this planktonic diversity and the underlying mechanisms causing differences in community composition is a challenging and central goal for ecologists. However the information about long-term dynamics (centennial to millennial periods) of planktonic assemblages are lacking and thus hamper our ability to explore the links between planktonic diversity changes and environmental forcing factors (among which climate change). The coupling between molecular tools (sequencing of environmental DNA) and paleolimnology offers a unique opportunity to reconstruct the lacustrine biodiversity on long-term time scales. We illustrate here the application of such coupling. The results provide a temporal view of the diversity of microbial eukaryotes groups (phytoplankton and non-pigmented eukaryotes) based on the sequencing of DNA preserved in the sediments. The temporal scale investigated here is up to 2200 years. A large diversity was retrieved from sedimentary DNA, with for instance 16 000 OTUs detected for microbial eukaryotes distributed within 61 phylogenetic groups. From alpha and beta diversity metrics we revealed change points of biodiversity (i.e. marked rearrangements in the structure of the targeted biological communities) related to climatic periods (little ice age, medieval or recent warming); however the impact of eutrophication, when reaching a certain threshold, overpassed the effect of climatic fluctuations, as observed in the eutrophicated subalpine lake Bourget.

These data confirm that the analysis of genetic signatures preserved in sediment archives could greatly enrich our knowledge of past ecosystems by revealing biological assemblages that were not studied previously due to the absence of identifiable remains in the sediment record.

02-P   Revised nomenclature for Charophyta species' from Slovakia and new additions. *Ladislav Sallai, Thomas Smith*

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The purpose of this project is to revise the documented Charophyta species' nomenclature from Slovakia and add new records documented.   The up-to-date name changes were derived from the AlgaeBase internet resource (www.algaebase.org).   The nomenclature reflects the current taxonomic understanding for previously recorded Charophyta species.   There are a total of 5 classes (Charophyceae, Coleochaetophyceae, Conjugatophyceae, Klebsormidiophyceae and Mesostigmatophyceae). Conjugatophyceae was the largest class and represented by two Orders Desmidiales (Family: Closteriaceae, Desmidiaceae, Gonatozygaceae, Peniaceae) and Zygnematales (Family: Mesotaeniaceae and Zygnemataceae). Coleochaetophyceae was represented by two Orders Chaetosphaeridiales (Family Chaetosphaeridiaceae) and Coleochaetales (Family: Coleochaetaceae). Charophyceae was represented by one Order Charales and one Family Characeae. Klebsormidiophyceae was represented by one Order Klebsormidiales and one Family Elakatotrichaceae. Klebsormidiophyceae was represented by one Order Mesostigmatales and one Family Mesostigmataceae.   There are a total of 850 species (763 Conjugatophyceae, 63 Charophyceae, 16 Klebsormidiophyceae, 7 Coleochaetophyceae, 1 Mesostigmatophyceae) have been identified.

02-P   Nutritional quality of fish faeces is enhanced by swarming of essential fatty acid-producing Protozoa. *Megumu Fujibayashi* [1] - *Nobuyuki Tanaka* [2] - *Aya Takasawa* [2] - *Shun Hashido* [2] - *Kunihiro Okano* [1] - *Osamu Nishimura* [2] - *Naoyuki Miyata* [1]

Akita Prefectural University, University, Akita, [1] - *Tohoku University, University, Sendai,* [2]

Essential fatty acids (e.g. 20:5n3, 22:6n3) are indispensable nutrients for all animals. Animals have to acquire essential fatty acids from diets because most of animals can't synthesize enough amount of essential fatty acids for meeting their requirements. In aquatic ecosystems, main producers of essential fatty acids are algal species. For instance, 20:5n3 is produced by diatom. In a previous study, however, 20:5n3 was detected from faeces of freshwater fish, *Danio rerio* which were raised with single diet of green algae which does not contain 20:5n3. While protozoa, some of which have been suggested to have an ability of essential fatty acid synthesis were also found in faeces, we hypothesized detection of 20:5n3 from fish faeces is attributed by attached protozoa. To confirm this, a laboratory feeding experiment with *D.rerio* and green algae as 20:5n3 free diet was conducted. Results showed that there was a significant positive relationship between the cell number of protozoa and concentration of 20:5n3 in faeces. Interestingly, another laboratory experiment demonstrated that protozoa were much more detected from faeces than leftover of green algal diet. This indicates that protozoa swarmed on faeces preferentially. Furthermore, we cultured some species of protozoa with a 20:5n3 free medium. We detected 20:5n3 from *Cyclidium* sp., suggesting it synthesized 20:5n3 de novo. It is expected that protozoa have a role of producer of essential fatty acids and enhance the food quality of animal faeces for detritus based food webs in freshwater ecosystems.

02-P   Inorganic carbon acquisition linked to ecological preference in four green microalgae. *Sabrina Lachmann* [1] - *Elly Spijkerman* [1] - *Stephen Maberly* [2]

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The effects of CO_2 supply, P-limitation and pH play an important role in algal ecology. Microalgae possess a range of different inorganic carbon (C_i) acquisition strategies to maximize growth rate and these are influenced by several environmental factors including pH, light and nutrient availability.
We studied four species of green microalgae (Chlorophyceae) that vary in their habitat preference, especially for pH. The effects of varying culture CO_2 and P concentrations and pH on different parameters of C_i acquisition, using pH-drift experiments and C_i uptake kinetics, were determined. Moreover, these algae were analysed in their pH tolerance expressed by various growth rates.

Our results indicated a significant influence of external pH on growth due to varying pH preference as well as on c_i acquisition in all four species. Values of pH at the end of the pH-drifts and c_T/alkalinity quotients (we defined 'c_T'' as 'c_i at the end of a drift') varied among algal species and therefore led to different efficiencies of c_i uptake and c_i species used. The acidophile and acidotolerant *Chlamydomonas* species were mainly restricted to CO_2, whereas the two neutrophiles were efficient bicarbonate users. CO_2 concentration and pH only affected c_T/alkalinity quotients in acidophile and acidotolerant algae suggesting that neutrophiles have a higher plasticity to acclimate during pH drift. The development of the photosynthetic rate during a pH-drift showed that cultures acclimated to high CO_2 adapted rapidly to low CO_2 condition during a pH-drift. c_i uptake kinetics at different pH values revealed that external pH had a large influence on the affinity for c_i during measurement, which was highest under conditions where CO_2 dominated the c_i pool, but less influential to photosynthesis when varied just during growth. P_i-limitation mainly resulted in a decreased maximum c_i-uptake rate, but was of less influence on the affinity for c_i-uptake. Possibly a P_i-limitation will not influence c_i-uptake in nature as growth will be largely decreased.

In conclusion, c_i acquisition was highly variable within a single phylogenetic group of green algae and linked to growth pH preference, suggesting that there is a connection between c_i acquisition and ecological distribution. Moreover the results imply the importance of c_i (and pH) as an important ecological factor and indicate highly variable properties in competition for c_i between species of green microalgae.

02-P   Periphytic diatoms as indicators of trophy in shallow tropical reservoirs. *Fernanda Ferrari* [1] - *Carlos Eduardo de Mattos Bicudo* [2]

Universidade Tecnológica Federal do Paraná, Universidade Tecnológica Federal do Paraná, Dois Vizinhos, Brazil [1] - *Instituto de Botânica / Secretaria do Meio Ambiente de São Paulo, Instituto de Botânica / Secretaria do Meio Ambiente de São Paulo, São Paulo, Brazil* [2]

This study was carried out in two shallow tropical reservoirs with different trophy located at the Parque Estadual das Fontes do Ipiranga, Municipality of São Paulo. The objectives were to evaluate the potential of periphytic diatoms in assessing the trophic state of the reservoirs and verify if differences in habitats of reservoirs and temporal scale influence the trophy indicator potential of assemblage. Sampling of periphyton growing on artificial substrate was carried out monthly during 12 consecutive months at the subsurface of pelagic and littoral zones of IAG Pond (oligotrophic) and pelagic and two littoral zones of Garças Pond (hypertrophic). Descriptive statistics and multivariate analysis were used to evaluate data. Three sample unities' groups were discriminated in relation to their diatom species composition and abundance. The groups formed were mainly related to differences in the conditions of conductivity, pH and nutrient concentrations (trophy) of reservoirs and secondarily to light availability and disturbance. Group 1 included all oligotrophic reservoir sample unities (lowest values of conductivity, nitrogen and phosphorus) and was represented by diatom taxa sensible to high nutrient concentration and pH. Groups 2 and 3 included hypertrophic reservoir sample unities (greatest values of pH and nutrients) and was formed by diatoms taxa tolerant to high concentrations of nitrogen, phosphorus and elevated pH. Besides in the same hypertrophic conditions, sample unities of groups 2 and 3 showing tendency of separation. For group 2, where were registered elevated light values, S-strategists with greater competitive ability for using resources and supporting positive growth rates, were selected as indicator species. Group 3 was composed by C-strategists, besides S-strategists, with great competitive capacity under optimal resources availability conditions, and by r-strategists adapted to disturbance. Group 3 included sample unities of the end of the rainy period and of most of the dry one characterized, respectively, by greater pluviometric precipitation and greater resources availability. Besides differences in assemblage composition, all species selected as potential indicators in the groups corresponding to hypertrophic reservoir are similar in environmental requirements. Then, although taxa dominance can vary along climatic periods in the year, in comparable trophy conditions, the tolerant/sensible categories of taxa remain the same.

02-P   Growth characteritics and zygospore formation of the filamentous *Mougeotia*, Lake Suwa, Japan. *Noriko Futatsugi, Rie Saito, Koji Tojo, Ho-Dong Park*

Faculty of Science, Shinshu University, Matsumoto, Japan

In Lake Suwa (Japan), the blue-green alga *Microcystis* dominated in every warm season from the late 1960s until 1998. After that, *Aphanizonmenon* and diatoms dominated every year. *Mougeotia*, which is a filamentous green algae often

found in deep large lakes and acidified lakes, appeared in August 2011 after a clear water phase caused by heavy and frequent precipitation in July. Since then it started appearing every year. DNA analysis of the 18S rRNA region of *Mougeotia* revealed that the strain in Lake Suwa comes from two phylogenetic clades. A genetic distance (p-distance) of 4% indicated they are strongly differentiated and should be recognized as different species. This work has shown that there are two different phylogenetic clades of *Mougeotia* in Lake Suwa, both of which are different from *M. scalaris* clades. The shape of zygospores in January 2012 and October 2015 suggests that they should belong to the species *M. elegantula*.

Furthermore, underwater light intensity and lower pH were recognized as important factors influencing the development of *Mougeotia*. Investigating the growth characteristics of *Mougeotia* is relevant because the massive growth of this species may impair fishing tools (cast and gill nets) and result in a nuisance to local fisheries.

03. THE BORDERLINE WORD OF INLAND WATERS: WETLANDS AND ESTUARIES

03-O Preliminary evidence of effects of *Phragmites australis* growth on N_2O emissions by laboratory microcosms. *Xiaozhi Gu, Kaining Chen , Chengxin Fan*

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Denitrification has been found to play a significant role in the nitrogen (N) biogeochemical cycle of riparian wetland systems; however, there is little understanding of the role of emergent macrophytes in sediment denitrification. In this study, laboratory culture experiments were conducted to examine how *Phragmites australis* growth affected N_2O emissions. Additionally, preliminary investigations into the variability of carbon and available NO_3^--N fractions were conducted. The N_2O emission rate was quantified based on the high-resolution N_2O microprofiles in acetylene-inhibited sediment cores. Seasonal-dependence of N_2O emission was remarkable throughout incubation of both *P. australis* rooted sediments and control with no *P. australis*, and increased significantly with biomass steady accumulation ($p<0.05$), reaching a peak emission of 630 ± 15 µmol $N_2O\cdot m^{-2}$ d^{-1} at day 180 (in late autumn) in the *P. australis* rhizosphere. Simultaneously, N_2O emissions were more highly influenced by fine-root biomass, belowground biomass and plant height than total biomass, root activity and relative growth rate in the Spearman rank correlation model. More specifically, based on the strong and significant ($p<0.01$) positive correlations between hot-water extractable carbon (HWC) and N_2O emission flux, the rapid transformation indicated that changes in the HWC (ranging from 720 to 3564 mg kg^{-1}) with plant growth could reflect a 14-fold variation in N_2O emissions during the growth stage, and that N_2O emissions were highly dependent on fine-root biomass and its delivery of organic carbon. The ion exchangeable form NO_3-N (IEF-NO_3-N) in sediments was found to be the predominant transferable form involved in denitrification, while the iron-manganese oxide form NO_3-N (IMOF-NO_3-N) can be considered as a potential source of nitrogen for denitrification. This study highlights that emergent macrophyte communities dominate riparian ecosystem denitrification and that the metabolic mechanisms of emergent macrophytes can have positive feedbacks on the HWC fraction and available NO_3-N combined with sediment components in rhizosphere sediments.

03-O Leaf litter decomposition and invertebrate diversity in upland peat associated swamp streams in eastern New South wales, Australia: the influence of urbanisation. *Lorraine Hardwick [1] - Grant Hose [1] - Kirstie Fryirs [2]*

Department of Biological Sciences, Macquarie University, Sydney, Australia [1] - Department of Environmental Sciences, Macquarie University, Sydney, Australia [2]

The Blue Mountains rise to 1,189 m above sea level on a sandstone escarpment near Sydney, Australia. Accumulation of sediments on shallow valley floors atop the plateau since the Holocene have formed extensive valley fill swamps (Fryirs, 2014a). These heavily vegetated swamps are formed on complex strata of terrestrial peat and sandy sediments. Due to their globally acknowledged high biodiversity, threats and endemicity, they are protected under Australian Biodiversity legislation. Swamp hydrology is complex and may be entirely ground water based, fully channelized or some combination of both (Fryirs, 2014b). Vegetation complexes are generally xerophytic, with acidic, low nutrient water chemistry (Keith 2004). Aquatic ecological processes are poorly understood. As natural systems they are viewed as ecological filters, improving downstream water quality in Sydney's water catchment.
This study investigated decomposition processes and related invertebrate utilization in six small streams associated with upland peat swamps on sandstone in the Blue Mountains, west of Sydney, NSW, Australia. Increasing urbanization is impacting on these fragile swamps, altering hydrology, increasing nutrient runoff and creating channelized, dewatered systems (Fryirs, 2016). The objectives were to identify processes of leaf litter decomposition (mesh size, composition of litter, invertebrate use) related to natural and anthropogenic impacts on water quality.
Streams were chosen based on the proportion of catchment impervious cover, in order to understand processes involved in the urban stream syndrome (Walsh et al 2005). In May 2015, six replicated litter bags containing mixed eucalypt leaves and of differing mesh size (150 micron, 1 mm, 9 mm) were placed in pools downstream of swamps.

Litter bags were harvested at durations up to 10 months, with the litter components separately air dried and weighed for mass loss. Organic matter loss was measured by loss on ignition. Downstream nutrients and water quality were altered by urbanization. Leaf litter decomposition increased with nutrients up to thresholds where dissolved oxygen levels were depleted. Invertebrate communities responded by an increase in tolerant taxa. Shredding invertebrates such as Calocidae used aged leaf material preferentially and litter decomposition was more rapid in litter bags with larger mesh size. This study provides some understanding of ecological processes in natural and impacted peat swamp systems in eastern Australia.

03-O   The effect of temperature on nitrogen removal from treated waste water by denitrification: laboratory experiment with lake sediment.   *Jussi Huotari*[1] *- Satu Nokkonen* [2] *- Sari Uusheimo* [1] *- Tiina Tulonen* [1] *- Sanni Aalto* [3] *- Marja Tiirola* [3] *- Jatta Saarenheimo* [3] *- Antti Rissanen* [4] *- Lauri Arvola*[1]

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Treated waste water contains vast amount of nitrate still readily to be reduced to dinitrogen gas, and subsequently emitted to the atmosphere, by the microbes in freshwater sediments. Therefore, one can expect nitrogen (N) removal to be increased by spatially optimizing treated waste water discharge from treatment plants to the sediment surfaces of recipient waters. Tightening regulations by European Union requires enhanced N removal from waste water before it enters the waters sensitive to N loading. Thus, this ecosystem service provided by inland water sediment microbes should be taken into account as an additional and cost-effective N removal strategy. Whether this ecosystem service is effective and can be utilised in northern latitudes with strong seasonality is poorly understood, as low temperatures can be expected to lower microbial activity in winter.

To address this issue, we conducted factorial experiment to study the effect of temperature as well as water residence time on the efficiency of sediment microbes to remove N from treated waste water by denitrification. In replicated flow-through systems treated waste water with the nitrate concentration of about 20 mg/L was gently discharged on a surface of the sediment for 45 days. Sediment was collected in winter from a site where treated waste water is drained to a shallow bay of a lake. Triplicate containers were set up at 5, 15 and 25°C to resemble natural temperature range at the lake, and kept in dark to prevent any autotrophic uptake of N. Denitrification rate was estimated in 2-3 day intervals from nitrate concentration difference between outlet and inlet. Total N removal was measured four times during the experimental period from differences in total N concentrations. Flow rate was lowered between days 10-31 so that water residence time was 5 days, while the residence time was 2.5 days during the higher flow rate in the initial and the end part. In addition, also ammonium, phosphate, total phosphorus and dissolved nitrous oxide concentrations were measured in the beginning, when the flow rate was changed and at the end of the experiment. Denitrification rate was measured with ^{15}N isotope pairing technique once in 5°C and twice in 15°C. We also took samples for sediment quality and microbial community.

In the beginning, a decrease of nitrate concentration was largest at 5°C, whereas ammonium and total N increased. However, towards the end of the experiment nitrate reduction clearly increased at 25°C relative to others. At the end of the experiment, N removal efficiency was steadily increased to almost 30% in 25°C while it was about 5% in lower temperatures. The effect of residence time was unclear although nitrous oxide concentration was increased at 5°C when the residence time was longer. We will discuss possible causes for the observed differences and the exploitability of freshwater sediments as additional and cost-effective year-round N removal strategy for waste waters.

03-O   Tracing freshwater-saltwater exchange and biochemical cycling using continuous radon and chemical measurements on a barrier island (Spiekeroog, Northern Germany).   *Clarissa Glaser*

Departement of Hydrology, University of Bayreuth, Bayreuth, Germany

The Wadden Sea of Northern Germany is one of the largest regions shaped by tidal processes in the world. The large tidal range has a significant influence on hydrological processes such as water fluxes and nutrient cycles. The aim of this study was to show that 222-radon can be used as natural tracer for the investigation of the exchange of freshwater and saltwater in a tidal flat. Furthermore tidal cycling of nutrients such as Dissolved Organic Carbon (DOC), Fe, P and NO_3

was observed. The interaction of freshwater and saltwater was studied on the barrier island Spiekeroog which is located in the North Sea on the coast of Northern Germany. Continuous radon measurements has mostly be done in the laboratory or over only short periods. Here we measure radon directly in situ in the water with a mobile radon-in-air monitor (RAD7) coupled with a special hydrophobic membrane with a high permeability with regard to radon diffusion. The aims were to find a correlation between the tidal range and the amount of radon due to the influence of radon enriched fresh groundwater during low tide. The exchange of nutrients depends on whether the nutrient arose from the freshwater lens, sea water or chemical interactions in the sediments during tidal cycling. High concentrations of nutrients during low tide are a hint for the influence of the freshwater for the concentrations.

03-O   Use of bioacoustic technology to understand wetland use by amphibians in Northern Alberta, Canada.   *Paszkowski Cynthia, Annich Natasha, Bayne Erin*

Department of Biological Sciences, University of Alberta, Edmonton, Canada

Boreal wetlands are being destroyed or altered by large scale energy-sector development in the Lower Athabasca region of Alberta, a 93,527 km2 area which includes the oil sands. Unfortunately, knowledge of the distribution and habitat use of many wetland-dependent vertebrate species in this region is poor. We are employing Autonomous Recording Units (ARUs) to survey for presence/absence of five species of anuran amphibians, with a focus on the Canadian toad (Anaxyrus hemiophrys). This species is of conservation concern in Alberta, but it is cryptic, thus information on its ecology is limited.

Our long-term goal is to produce predictive, habitat-use models for Canadian toad based on landscape variables. From 2013-2015, we installed ARUs at a total of 995 unique wetland stations in the study region. Recordings were made during the breeding season for anurans (April to July), daily on the hour for 10 minutes. Each station was assigned a habitat type based on the Ducks Unlimited classification system (bog, fen, marsh, swamp, open water, upland forest). We also collected landscape data on soil characteristics, and the nature and extent of human disturbance. Acoustic data were processed through human listening and computer-recognition software.

ARUs detected Canadian toad at 167 locations. The species "selected" open-water wetlands (fens and marshes) for breeding, in close proximity to upland vegetation. Sites were characterized by soils with coarser textures, moderate drainage, and a predominance of sand. Our results indicate that ARUs are a promising technology for mapping the distribution of wetland species that rely on vocal communication, such as amphibians, birds and mammals, over large, remote geographical areas. Managers can pair results of bioacoustic surveys with large-scale spatial data to formulate strategies for identifying and preserving habitat for species of conservation interest.

03-O   Atanasovsko Ezero (Bulgarian Black Sea coast): most important site of the Bourgas wetlands for the western palaearctic migrating and wintering water birds – victim of its success?   *Caterina Casagranda, Stefania Klayn, David Martin Gallego*

Institute for Biodiversity and Ecosystem Research, Bulgarian Academy of Science, Sofia, Bulgaria

The Bourgas wetlands play an important role for the Western Palearctic migrating and wintering water birds. Together with the Danube delta, they constitute a stopover place on the Western Palaearctic migratory route, "Via Pontica". Atanasovsko Ezero is the most important site of the Bourgas wetlands with bird densities of up to 2 times more than on the other sites, and are made up principally by waders. As such, Atanasovsko Ezero fuels nutrients and organic matter transport across terrestrial, freshwater and marine habitats. Sediment-associated biota are integral to these functions. Nevertheless, functioning of the Atanasovsko aquatic ecosystem is poorly known. This constitutes an important handicap to update the management plan as well as to implement the Natura 2000 directive and the current Ramsar Strategic Plan.

Since 1906, Atanasovsko Ezero is used for salt production. For this purpose, the successive construction of drainage canals in the surrounding marshes and a system of dykes, embankments and wooden locks has transformed the formerly brackish estuarine wetland in an entirely man-controlled complex of shallow evaporation and crystallization basins for salt-extraction. Seawater is moved consecutively from basin to basin so that the water has enough time to increase salinity.

A study on the water bird-macrozoobenthos trophic relationship between May 2011 to January 2012 revealed that following the technical water movement, a complete functional benthic assemblage supporting wading birds in the first

basins changed successively into to a benthos-poor algal mat without feeding birds in the end-term basins. Water birds, where present, are concentrated on emerged mud or dykes, resting and roosting, and an important amount of feces has been observed. The trophic state of the incoming seawater was evaluated in terms of total N and Chl *a* values as oligo-mesotrophic. The water in the end-term basins of the technical water movement can be classified extreme hypertrophic. According to the saltworks, phytoplankton blooms are regular in these basins. The man-made isolation from land and sea and the defecation of birds that use the dykes as resting places are likely to have put the lagoon over the last century under a regime of self-putrefaction. We hypothesized that the cumulative amount of benthic biomass removed by feeding water birds is in the long term limited by the renewal rate of benthic food stocks. Hardly another place such as Atanasovsko Ezero could be found where habitat alteration is both so attractive and repulsive for water birds. The positive aspect is that the saltworks themselves are interested in improving the water quality.

Many more questions arise from these findings than answers are provided. What is the role of this algal mat, is it a first state of an succession or has it a positive feedback to eutrophication ? How can the dyke system be improved that should meet various conditions: divide water body in ponds, reduce velocity of water-flow while increasing pond circulation, cheap construction, easy maintenance, provide resting and nesting grounds for birds, avoid approach of predators (dogs, jackals)? The objective of this presentation is to stimulate debate on restoration measures of functional diversity and have a scientific feedback on comparative and manipulative approaches.

03-P In situ diurnal denitrification activity of stream sediments measured by ^{15}N technique. *Sari Uusheimo [1] - Lauri Arvola [1] - Sanni Aalto [2] - Tiina Tulonen [1]*

Lammi Biological Station, Helsinki University, Hämeenlinna, Finland [1] - Section of Environmental Science and Technology, Jyväskylä University, Jyväskylä, Finland [2]

Denitrification is a process where nitrate-nitrogen (NO_3^--N) is reduced to nitrogen gas (N_2) and it is regarded as the most important pathway removing permanently nitrate and nitrite from inland waters. This anaerobic process is dependent on oxygen conditions, as denitrifying bacteria prefer oxygen gas (O_2) instead of NO_3^--N in their respiration. Previous studies have shown, that diurnal light:dark cycle affects sediment dissolved oxygen (DO) conditions. Only few studies have been performed, however, to show how diurnal variation in DO concentration and illumination affects denitrification in stream sediments. In August 2014 and 2015, we investigated diurnal denitrification rates of a second-order boreal stream in periods of 3 hours. We used ^{15}N isotope-pairing technique and *in situ* incubations for the measurements. The stream (Koiransuolenoja, Finland) is heavily influenced by a loading from agriculture, and its NO_3^--N concentrations are high especially during high-flow. In addition to the denitrification measurements, DO profiles of the upper sediments were measured by a microelectrode. Photosynthetically active radiation (PAR) and water temperature were measured during the study periods. The results showed, that denitrification rates more than doubled during the night in comparison to the day. The lowest denitrification rates were measured right after noon, at time of high illumination. The average denitrification rate varied between 86-891 and 400-2198 µg N h^{-1} m^{-2}, respectively. Most of the denitrification was based on the nitrate diffusing from the water above the sediment into the denitrification zone. A negative correlation was found between denitrification rate and DO penetration depth (r = - 0.634, p < 0.01) and between denitrification rate and oxygen concentration in sediment-water interface (r = - 0.560, p < 0.01). This implied that in sediments with primary producers PAR is controlling photosynthesis, which through water and sediment DO conditions may, in turn, affect denitrification activity of the sediment. Therefore, denitrification rates measured only during daytime may be underestimations in shallow waters with epiphytic and epipelic algae.

03-P Nitrogen and phosphorus dynamics in a shallow pond loaded by purified wastewater. *Lauri Arvola [1] - Sari Uusheimo [1] - Jussi Huotari [1] - Josefiina Ruponen [1] - Sanni Aalto [2] - Marja Tiirola [2] - Antti J. Rissanen [3] - Jatta Saarenheimo [2] - Tiina Tulonen [1]*

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Modern wastewater treatment plants (WWTP) usually retain >95% of inflowing phosphorus while their nitrogen retention efficiency can be much lower. In the Baltic Sea, nitrogen can be the limiting nutrient for algal growth and nitrogen limitation may also take place in lakes. In Finland, the number of WWTPs is >300, and many of those drain

purified wastewater through artificial wetlands and/or ponds to the recipient lakes and rivers. The rationale is that wetlands and pond systems will retain nutrients before the purified wastewater finally reach the downstream water system. Although this has been the practice for a long-time, little is known about the food webs and processes involving nutrient retention in ponds. This is true especially when the different seasons are considered, a knowledge that is important in areas with long winter. We estimated nitrogen and phosphorus retention in a study pond, located in Sothern Finland, during one year based on fortnightly-once in three weeks sampling. Besides the inflowing and outflowing discharge and nutrient measurements, we measured the abundance and biomass of bacteria, phytoplankton and zooplankton, as well as chlorophyll a concentration. Dissolved oxygen concentration was measured with high-frequency by DO sensors at the surface and close to the bottom of the pond. In addition, denitrification activity in sediments was measured by ^{15}N- technique (IPT). Since end of March until end of November the retention varied on average between 77-85% for the dissolved fraction of N and P, being 38% for TP, 72% for TN and 13% for DOC. In summer, plankton organisms were mostly responsible for the uptake of nitrogen and phosphorus, and as a result the biomass of algae, bacteria and zooplankton was high. The maximum chlorophyll a concentrations were >500 mg m^{-3} and DO saturations >250%, indicating extremely high primary production. The results will be discussed in the context of water purification, nutrient uptake and eutrophication of lakes.

03-P Nitrate transport, retention and denitrification activity in an agricultural stream with constructed ponds.   *Tiina Tulonen, Sari Uusheimo, Jussi Huotari, Lauri Arvola*

Lammi Biological Station, University of Helsinki, Hämeenlinna, Finland

High nitrogen transport from agricultural lands, mainly in the form of nitrate, is typical in first and second order streams and ditches. Substantial investments are made to reduce the nutrient loading by constructing wetlands and sedimentation ponds, but still the nitrogen transformation processes in these waterways is poorly understood. Aim of this study was to investigate on annual basis the role of denitrification microbes in reducing nitrate loading from agricultural watersheds because denitrification process is an important pathway for permanent nitrate removal from the system.

Nitrogen transport, retention and potential denitrification activities were investigated in years 2013-2015 in a small boreal watershed (mean runoff 70 l s^{-1}, catchment area 6,9 km^2 consisting 24% of agricultural land). Three consecutive sedimentation ponds with bottom dams between the ponds, having a total area of 1247 m2, were built about 200 meters upstream from the lake inlet. Water residence time varied from hours to few days. Nitrate concentrations and runoff were measured weekly/biweekly from two points, before and after the sedimentation ponds. Denitrification rates were measured six times during the study period, between May and October, from sediment cores (stream, 2 littoral and 3 deep sites in ponds) using ^{15}N labelling and isotope pairing technique (incubated in laboratory at +18° C in dark for 3h).

Nitrate transport from the catchment was on average 3,3 kg km^{-2} d^{-1} (range 0,3-56,1 kg km^{-2} d^{-1}) with the highest peaks occurring during spring and autumn floods. During May-September, when loading was averaged 1,7 kg NO$_3$-N km^{-2} d^{-1}, mean nitrate retention in the sedimentation ponds was 4,8 %. During summer months (Jun-Aug) nitrate retention was 8,2 %. Leakage of nitrate from the ponds was observed in autumn, winter and spring. In summer nitrate reduction by denitrifying microbes comprised 6-38 % (45-110 g N d^{-1}) of the total indicating the importance of other processes like uptake of nitrate by plants and periphytic algae. In autumn when senescence of vegetation resulted leaching of nitrate, denitrification processes had more important role in the total nitrate reduction. The results showed that constructed wetlands and ponds can effectively reduce nitrate during the warmest period of the year, however the role of denitrification processes being of minor importance. Further interest will be focused on factors affecting denitrification processes in ponds.

03-P   Wetland diversifies bacterial populations in river.   *Young-Ok Lee [1] - Sun-Ja Cho[2]*

Division of Biological Sciences, Daegu University, Kyung-san, [1] - Department of Microbiology, Pusan National University, Pusan, [2]

In order to determine how a wetland habitat affects bacterial diversity, sediment samples were collected from three sites with different degrees of pollution, one of which is a wetland (site 4) in the upper course of a Korean river, Gum-Ho River, and two sites in the tributary of Gum-Ho River. Of the two sites (sites 1 and 2) in the tributary, the water at

site 2 is constantly contaminated by the discharge of effluent from a nearby municipal wastewater treatment plant (WWTP), whereas the water at site 1 is not. The metagenomic DNAs of the sediment samples were extracted and amplified with 27F/518R primers and then pyrosequenced with Roche 454 GS-FLX Titanium. The results were expressed as the ratio (%) of equivalent reads to total classifiable reads at the phylum level. The dominant bacterial phyla with more than 10% composition at all sites were Proteobacteria and Firmicutes. These were followed by Bacteroidetes, Actinobacteria, Chloroflexi Acidobacteria, Planctomycetes, Verrucomicrobia and Nitrospirae in varying proportions, depending on their ecological status of each site. Remarkably, spore forming Firmicutes were the most dominant at site 3 where the tributary (loaded by effluent from WWTP) merges with Gum-Ho River and at site 5, near the recreational water zone. Based on diversity evaluations using Shannon (H) and Simpson-index, the bacterial diversity in the water zone of the wetland (site 4) showed the highest value, even surpassing the measured value at the pollution free site 1. These findings indicate that the wetland has the capability to restore its ecology. Therefore, wetlands must be protected to preserve the ecological stability and biodiversity of the surface water.

03-P   An overview of the hypoTRAIN network topics: hydrology, secondary production and the bioreactor ability of the hyporheic zone.   *Ignacio Peralta-Maraver, Julia Reiss, Anne Robertson*

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The hypoTRAIN network is a multidisciplinary, international team of scientists who want to elucidate the importance of the hyporheic zone (HZ). Hyporheic zones are dynamic and complex transition regions between rivers and aquifers and they are characterized by the simultaneous occurrence of multiple physical, biological and chemical processes. Turnover and degradation of nutrients and pollutants are among the prominent ecological services the hyporheic zone provides. Here, we summarise current knowledge on the three main topics hypoTRAIN will tackle over the next three years.
[1] Hydrology methods: Hydrology and substratum characteristics have great influence on the ecological processes and assemblage of organisms (hyporheos) in the hyporheic zone and therefore assessing these hyporheic features is critical in hyporheic ecology. Here we summarize and describe some of the most popular techniques used to assess hydraulic exchange and flow paths thorough the HZ, most of which have been almost exclusively used in the field of hydrology and engineering.
[2] Secondary production: Although one of the main ecological processes of the hyporheos is their contribution to the production of the whole system, quantifying this production and comparing it with other river compartments is very rare. We conducted a literature search in order to compare invertebrate secondary production in benthic vs hyporheic zones (< 10 cm sediment depth) in different streams. We found that hyporheic zones contribute substantially (16-50%) to total invertebrate production in the channel. This supports previous studies which have stressed the importance of quantifying hyporheic secondary production and its potential role in the Allen paradox.
[3] Bioreactor ability: Finally, it has also been proposed that productive and active communities maintain the bioreactor ability of the HZ to attenuate nutrient and pollutant concentration in freshwater ecosystems. Although the underlying mechanisms that result in this attenuation are still unknown, it is broadly accepted that bacterial activity plays a key role in this process. Concern over rising concentrations of organic micropollutants (such as pharmaceutical and personal care products) in streams and rivers has increased in recent years. We present a ist of identified bacteria with the potential capacity to remove these micropollutants in the HZ and discuss how invertebrates and nutrient supply are involved in this process.

05. THE IMPACT OF GLOBAL CHANGE ON INLAND WATERS

05-O   Recovery and non-recovery in the ecology of acidified streams. *Alan Hildrew* [1] *- Guy Woodward* [2] *- Katrin Layer* [2]

School of Biological & Chemical Sciences, Queen Mary, University of London, London, United Kingdom [1] *- Department of Life Sciences, Imperial College London, London, United Kingdom* [2]

Recovery and non-recovery in the ecology of acidified streams. Alan Hildrew, Guy Woodward & Katryn Layer. Reductions in acidifying atmospheric emissions are now widespread, and chemical recovery of acidified fresh waters is apparent. Any ecological reversal towards an 'acid-sensitive' invertebrate assemblage is much less obvious, however. Possibly chemical recovery is still not sufficient, or dispersal to the newly recovered systems may be slow. There is circumstantial evidence, however, that interactions among acid-tolerant and acid-sensitive species may be inhibiting the simple return of the latter. There may be competition for food between acid-sensitive specialist grazers and acid-tolerant generalists, and greater vulnerability of recolonizing herbivorous prey to acid tolerant invertebrate predators. Analyses of food web stability also suggest that simplified webs of acid streams are resistant to extinctions (and thus perhaps to reversal from acidification). Recent evidence also shows that the rate of decomposition is increasing as streams de-acidify, and that food chains have got longer although without wholesale species change lower in the web. Finally, it is unlikely in any case that the 'target' for recovery from acidification has remained the same, in the face of other stressors such as climate change.

05-O   Salmon and trout population dynamics; insights from a 22 year study in an Irish river catchment.   *Hugh B. Feeley* [1] *- Jan-Robert Baars* [1] *- Fiona Kelly* [2] *- Mary Kelly-Quinn* [1]

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Recent research has highlighted the volume, value and economic impact of recreational angling in Ireland. In summary, annually up to 500,000 individuals participate contributing approximately €836 million to the Irish economy and supporting 11,000 jobs nationally. Atlantic salmon (*Salmo salar*) and brown trout (*Salmo trutta*) angling is particularly important but ongoing threats from pollution and potentially climate change may reduce the sustainability of fish populations in important angling rivers in Ireland. This study examines the population dynamics of brown trout and Atlantic salmon in the River Rye Water, an important tributary of the River Liffey on the east coast of Ireland. Annual fish surveys over 22 years (1994 to 2015) provide data on salmon fry and parr, and trout fry, parr and adult numbers. Results highlight variability and cyclic patterns in the number of Atlantic salmon fry, although parr numbers remain relatively stable over the study period. Brown trout fry numbers fluctuate less dramatically but densities of older fish are more variable than salmon parr. The goal of this study is to understand the relationship between stressors and salmonid population dynamics in this important fishery to determine factors controlling recruitment, survival, holding capacity and fish size. This will ultimately inform management and policy for the protection of this important cultural service in Irish freshwaters.

05-O   Trends and drivers of biodiversity of benthic invertebrates in European freshwaters.   *Gaute Velle* [1] *- Joseph Chipperfield* [2] *- Jens Arle* [3] *- Lars Eriksson* [4] *- Jens Fölster* [4] *- Iveta Indriksone* [5] *- Shad Mahlum* [1] *- Don Monteith* [6] *- Ewan Shilland* [7] *- Evzen Stuchlik* [8] *- Richard Telford* [2] *- Heleen de Wit* [9]

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London, United Kingdom [7] - Institute for Environmental Studies, Charles University in Prague, Prague, Czech Republic [8] - Norwegian Institute for Water Research, NIVA, Oslo, Norway [9]

This study includes analyses of trends and drivers of species diversity of benthic invertebrates in European rivers and lakes. The invertebrates were sampled at freshwater monitoring sites in the Czech Republic, Germany, Latvia, Norway, Sweden and the UK. The data includes about 1.8 million benthic macroinvertebrates from 5225 samples in 55 rivers and 34 lakes collected between 1982 and 2014. In addition, data on water chemistry, precipitation and temperature from the same sites and periods are included, where such data exist. The study sites forms part of national monitoring programmes and most represent sites of nutrient poor waters that have been influenced by long-range air pollution leading to acidification and are now in a process of chemical recovery. To our knowledge, no comparable studies on biodiversity exist at this scale.

Over the monitoring period, the concentration of sulphate has decreased, while pH and buffering capacity (ANC) have increased. A majority of the rivers and lakes (70 of 89 sites) show a net increase in species diversity (both richness and Shannon), albeit the increase is not statistically significant for all sites. The biodiversity of lakes has increased to a smaller extent than the biodiversity of rivers.

The biodiversity increase is correlated with sulphate (SO4), pH and monthly minimum temperature. There is no lag between SO4 or pH and a change in biodiversity. For temperature, a lag around one year provides the best fit, suggesting that the temperature now may influence the biodiversity next year. Pressure from acidification also influenced the stability of the biological community in rivers, with greater short-term variation in the invertebrate community during times of higher SO4. Likewise, the stability of the biological community of lakes could be linked to variation in mean monthly precipitation with greater short-term variation during times of low precipitation.

A Bayesian model predicts that if European water quality and environment stabilises, then a continued increase in biodiversity across nearly all sites is expected. However, the increase will be counteracted by any further regional increase in temperature.

05-O   Lakes as mere archives or active upgraders of organic matter? – evidence of rapid biotic changes in pre-alpine Lake Lunz, Austria.

Martin Kainz [1] - Serena Rasconi [2] - Katharina Winter [1] - Stefanie Danner [1] - Hannes Hager [1] - Lisa-Maria Hollaus [3] - Samiullah Khan [1] - Jakob Schelker [3] - Elisabet Ejarque [1] - Tom Battin [4]

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Within lake catchments, organic matter (OM) is delivered to lakes by inflowing water, retained in biota and sediments, respired, and also discharged into outflowing streams. In this multiannual field study (2013-2015), we investigate the quantity and biochemical quality of OM in the pre-alpine, oligotrophic Lake Lunz, Austria, and hypothesized that, irrespective of seasons, inflowing water and settling particles contain predominantly recalcitrant particular OM (POM; >1.2 um particle size), whereas outflowing lake water is mostly composed of more labile, algae-derived POM. We collected POM at a monthly basis from lake in- and outflow, and as settling POM and in lake sediments. In addition, we investigate annual sedimentation rates (using ^{137}Cs and ^{210}Pb), time integrated loads of settling particles, analyze stable carbon (δ^{13}C) and nitrogen (δ^{15}N) isotopes to track changes of carbon sources and trophic compositions, respectively, and use source-specific fatty acids as indicators of allochthonous, bacterial, and algal-derived OM. Preliminary results indicate that, independent of seasons, inflowing POM is rich in terrestrial markers, as evidenced by long-chain saturated fatty acids, with little contribution of autochthonous stream POM, such as algae-derived long-chain polyunsaturated fatty acids (LC-PUFA). However, POM in outflowing water contains clearly higher contents of algae-derived, labile LC-PUFA. Settling particles include high contents of algae-derived OM, suggesting low degradation of such labile OM within the water column. However, LC-PUFA decreased rapidly in sediment cores below the sediment-water interface. Phosphorous concentrations remained stable throughout the sediment cores (40 cm), implying that past changes in climatic forcing did not alter the load of this limiting nutrient in lakes. Ongoing research investigates how much terrestrial and autochthonous POM is retained and processed in the lake and how organic matter sources changed during the past century as a result of recorded weather changes.

05-O   Chironomids taxocenosis in glacial areas, a long term study.   *Bruno Rossaro [1] - Giulia Magoga [2] - Matteo Montagna [2] - Valeria Lencioni [3]*

Department Food Environmental And Nutritional Sciences, Università degli Studi di Milano, Milano, Italy [1] - DISAA, Università degli Studi di Milano, Milano, Italy [2] – Museo delle Scienze, Trento, Italy [3]

The water bodies originating from the glacial areas, namely glacial streams (kryal), cold springs and small lakes, are inhabited by a rich fauna dominated by Chironomids belonging to the genus *Diamesa*. A review of the information gathered in glacial areas of the Southern Alps over a period of approximately four decades is here presented.
Despite a substantial change in the community composition cannot be observed, subtle changes in species composition and distribution can be detected.
Noteworthy, the available data emphasize that information on species presence and distribution is still well below a comprehensive knowledge, indeed species new to the Italian fauna can still be captured. It is not expected that some species can disappear, until the glacier areas persist, since the small size of Chironomids probably allows a species to be maintained even in a relatively small area suitable to their survival. Nevertheless the actual impressive shrinkage of glaciers suggests that all species characteristic of kryal habitat are at risk of extinction.
Common species well widespread in the glacial and nearby areas, such as *Diamesa tonsa, D. zernyi, D. bertrami and Pseudodiamesa branickii,* are accompanied by rare species strictly restricted to glacial habitat, such as *D. longipes, D. wulkeri, D. martae, D. nowickiana* and *Syndiamesa nigra.* These species were captured only in one locality and in one sampling date. The well-known glacier midge *D. steinboecki* is rather common in the Alps, but is strictly restricted to the uppermost reach of glacial streams. Other species, despite were captured in more occasions, are also restricted to glacial areas; most of them belong to the *Diamesa latitarsis* group (*D. latitarsis, D. modesta, D. goetghebueri* and *D. laticauda*). On the basis of the collected results it is possible to observe that in recent years it was necessary to move to higher altitudes, in concurrence with glacier retreat, to capture the species inhabiting the uppermost reach of glacial streams. *D. dampfi* characterize cold springs where the water temperature is always below 4°C, while *D. incallida* and *D. permacra* are cold stenothermal species living in springs with a water temperature near 8 °C*. Pseudokiefferiella parva* is characteristic of glacial stream colonized by mosses.
At present there is no evidence of biogeographic distribution within the Alpine area, with the possible exception of *D. cinerella*, which is widespread in the Alps but resulted more abundant in the West Alps, according to available data. *D. insignipes*, actually restricted to few localities of the Apennines, is the species of the genus that better tolerate the higher temperatures.
A last possible observation is represented by the fact that some Chironomids, being tolerant to higher water temperatures, are moving at higher altitudes; an exemplar case is represented by *Rheocricotopus fuscipes* (Orthocladiinae) formerly characteristic of Pre-alpine and lowland streams.

05-O   Water scarcity solution portends spread of aquatic invasive species.   *Hugh MacIsaac [1] - Doug Haffner [1] - Aibin Zhan [2]*

Great Lakes Institute for Environmental Research, University of Windsor, Windsor, Canada [1] - Research Center for Eco-environment Sciences, Chinese Academy of Sciences, Beijing, China [2]

Beijing is a megacity of 21 million people located in northern China. Over time, the city has experienced a decline in precipitation and an increase in the number of very hot (>35°C) days. The combination of a warmer, drier climate and increased demand for water due to population growth and urbanization has resulted in water scarcity, with per capita use (170 m^3 $year^{-1}$) far below the United Nations' absolute water scarcity threshold. In 1998 the government developed its Water Agenda 21 to address the issue, including creation of the South-to-North Water Transfer Project, the world's largest water diversion. The largest of the three routes in this Project is now transfering water 1273km from the Danjiangkou Reservoir in the south to the Miyun Reservoir in the north. The Miyun Reservoir (188 km^2) is the principal water source for Beijing. However, this new waterway will likely spread the golden mussel *Limnoperna fortunei*, a highly invasive biofouling species. In 2014, we sampled both reservoirs, and detected the species in abundance in the Danjiangkou, though traditional and molecular (cytochrome c oxidase subunit I (COI) gene) sampling and interviews with facility staff revealed the species is not yet present in the Miyun. The mussel is, however, found in another reservoir near Beijing, suggesting that the Miyun Reservoir and the canal feeding it will provide suitable habitat for the species. Systems in Asia and South America that have been invaded by this species typically experience dramatic changes in flow and ecosystem properties, thus we expect similar changes in the Miyun Reservoir once it is invaded. This Water Transfer Project provides an outstanding and unusual opportunity to conduct comprehensive sampling of an ecosystem prior to

its predicted invasion. More importantly, this study clearly links climate change, human population growth and spread of invasive species.

05-O   The importance of climate on stream diatom distributions.   *Virpi Pajunen [1], Miska Luoto [1], Janne Soininen [1]*

Department of Geosciences and Geography, University of Helsinki, Helsinki, Finland [1]

The responses of species distributions to global changes have recently received growing attention. The consequences of environmental changes are unpredictable especially in freshwater systems, where the driving forces of microbial species distributions remain poorly resolved. In fluvial ecosystems, unicellular diatoms are important primary producers and widely-used bioindicators as they respond rapidly to environmental changes, such as changes in water chemistry. Although the ecology of diatoms has been widely studied, effects of climate especially on stream diatom distributions have received less attention.
We investigated the relative influences of climatic and local environmental factors in explaining the distribution patterns of diatoms at 227 stream sites in Finland, northern Europe. The diatom species distributions were modelled using climatic and local environmental predictors with four different modelling techniques: generalized linear model (GLM), generalized additive model (GAM), boosted regression trees (BRT) and random forests (RF). Separate models were constructed for three sets of predictors: environment-only, climate-only and the full set of predictors. The predictive performances of the models were evaluated using the area under the curve of a receiver operating characteristic plot (AUC) and the true skill statistic (TSS) values by a four-fold cross-validation approach.
We found that the climate-only models outcompeted the environment-only models, and the full models had the highest predictive performance. The importance of explanatory variables varied among the species indicating that diatom species have unique responses towards environment and climatic conditions. Overall, growing degree days and conductivity had the greatest relative influences on species distributions in our data set. Our results indicate that both local environment and large-scale climatic variables are important drivers of stream diatom distributions. Even at regional scale, the climate-related variables may be stronger drivers than local variables, however, it is important to acknowledge and understand the joint effects of these drivers as the influence of climate is partly manifested through local variables.
Species-specific distribution models proved to be useful tools in explaining current microbial distributions and will help predicting the future distributions in changing environmental and climatic conditions. We found that it is important to include both climatic and local environmental variables in species distribution modelling of diatoms, yet we stress that it is essential to properly comprehend the indirect as well as the direct effects of climatic variables.

05-O   The effect of whole stream warming on insect emergence.   *Gisli Mar Gislason, Aron Dalin Jónasson*

Faculty of Life and Environmental Sciences, University of Iceland, Reykjavik,

A cold stream (IS7) in Hengill volcano 20 km east of Reykjavík was heated up by leading the stream water through a pipe into a heat exchanger in a nearby warm stream (IS8) and back to the lower reaches of the original stream. Emergence traps were placed in the unheated (7-10°C) and heated reaches (10-18°C) of the stream and in a warm stream (IS8) (19-22°C). This lead to a significant increase in total number of insects emerging from the heated stream. Of the total number of insects, Chironomidae were proportionally more numerous in the unheated reach compared with the heated reach, but blackflies and the predatory Limnophora riparia were both totally and proportionally more numerous in the heated reach. The fauna of the heated reach became more similar to the warm stream IS8. Warming up natural stream water by 3-8°C, a temperature increase expected at high latitudes in the next century, will result in increased density of aquatic insects and increased density of predatory insects, longer food chains and thus the height of the trophic network as a whole.

05-O Has mixotrophic metabolism been altered by climate-driven change after a decade? *Juan Manuel Gonzalez Olalla, Juan Manuel Medina Sanchez, Ismael López Lozano, Manuel Villar Argaiz, Presentación Carrillo Lechuga*

University of Granada, Granada, Spain

Mixotrophic algae constitute a key functional type in oligotrophic UVR-stressed ecosystems, such as high-mountain lakes. Because these ecosystems are sensitive to global change, mixotrophic metabolism may be affected by the interannual trend towards greater UVR-flow and frequency of mineral nutrients inputs linked to aerosol dust transport. Our prediction is that bacterivory linked to the mixotrophic metabolism will be a functional trait promoted in these ecosystems, and regulated by the balance UVR/phosphorus. To test our predictions, an extensive study was carried out in 13 high-mountain lakes in the National Park of Sierra Nevada (Spain) during the ice-free periods of two years spanning a decade (July-August 2005 and 2015). Bacterial production was regulated by the excretion of organic carbon (EOC) from phytoplankton, indicating a commensalistic dependence of bacteria on algal carbon, which was reinforced in the 2015 survey. Algal bacterivory was positively related to UVR/phosphorus ratio, suggesting that heterotrophy counterpart is promoted under conditions of UVR increase and P-limitation. Both findings support a dual control (predation-commensalism) of algae on bacteria as adaptive strategy for algae to overcome ultraviolet stress and P-limitation in these ecosystems. Notably, our results show that the bacterivory vs. UVR/phosphorus relationship did not significantly changed after a decade, suggesting the resilience of mixotrophy as a key functional trait in Mediterranean high-mountain lakes under climate-driven change.

05-O Increases in water temperature and heat waves induces loss in plankton biodiversity – evidence from a multi-seasonal mesocosm experiment. *Serena Rasconi, Katharina Winter, Stefanie Danner, Martin Kainz*

Wassercluster Lunz, Lunz Am See, Austria

Global climate change scenarios predict lake water temperatures to increase up to 4°C and heat waves to occur more frequently. Such changes will likely also affect primary production and thus the efficiency at which dietary energy is transferred to upper trophic levels. The aim of this long-term (12 months) mesocosms experiment was to explore how ambient water temperature (C; control), increased temperature (T: +4°C), and heat waves (HW: +/- 4°C relative to T) change phyto- and zooplankton phenology, taxonomical diversity, and community structure. Our results show that T and HW significantly changed phytoplankton diversity and community structure relative to C, whereas zooplankton abundance and composition was not significantly affected. Chlorophyta growth significantly increased in T compared to C and HW, while the HW caused significant increase of cyanobacteria growth compared to C and T. Phytoplankton richness (number of genera) declined continuously during the experiment and significantly in both temperature treatments compared to C. There was moreover a clear effect of the temperature treatments (T and HW) on phytoplankton size structure that resulted in a significantly lower growth of large species (i.e., large Chlorophyta). These preliminary results suggest that increased water temperature and extreme weather events induce loss of phytoplankton biodiversity. Continuous unstable environmental conditions may result in a reorganization of the phytoplankton community structure, characterized by the dominance of species that can endure such new climate scenarios.

05-O Seasonal epilimnetic temperature patterns and trends in a suite of lakes from Wisconsin (USA), Germany and Finland. *Richard C. Lathrop [1] - Peter Kasprzak [2] - Marjo Tarvainen [3] - Anne-Mari Ventelä [3] - Tapio Keskinen [4] - Rainer Koschel [2] - Dale M. Robertson [5]*

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Metrics of seasonal epilimnetic temperatures were computed for a diverse suite of lakes: Mendota, Monona and Devil's in southern Wisconsin, USA; Trout, Sparkling, Allequash, and Trout Bog in northern Wisconsin; Stechlin, Feldberger Haussee and Breiter Luzin in northeastern Germany; and Pyhäjärvi, Konnevesi and Kevojärvi across Finland. Most lakes

were regularly sampled since the early 1980s; Mendota, Trout, Stechlin, and Kevojärvi were also sampled in earlier years. For each sampling date, volumetrically-weighted mean epilimnetic temperatures were calculated from vertical profile data (0 m for Kevojärvi). First-of-the-month temperature metrics (1-May, 1-June, 1-July, 1-August, 1-September, 1-October, and 1-November) for each year were then computed by linear interpolation between sampling date temperatures. A July-August mean temperature was also computed.

Seasonal epilimnetic temperatures varied greatly between years due to variable weather. In the same region, temperature coherency (*r*) between lakes was high, but a shallow lake warmed faster in spring and cooled faster in fall than a deep lake. Coherency between the two Wisconsin lake regions was also high. Coherency was less but significant between the German lakes and the two southernmost Finnish lakes. Kevojärvi (arctic lake) had moderate coherency with the other Finnish lakes, but not with the German lakes. Coherency was not significant between the Wisconsin and European lakes. The previous month's starting lake temperature was a poor predictor of next month's starting lake temperature, whereas monthly mean air temperature was a significant predictor of next month's starting lake temperature.

Seasonal warming trends from the early 1980s to 2014 varied in the different lake regions. The two Wisconsin regions exhibited no spring epilimnetic warming whereas fall "warming" (delayed cooling) trends were statistically significant (+0.56 and +0.75°C per decade for 1-October in Mendota and Trout, respectively). Trends for July-August in the two lakes were not significant (+0.14 and +0.21°C per decade). For Lake Stechlin, 1-May and July-August had significant warming trends (+0.88 and +0.68°C per decade); 1-June and 1-October trends were not significant. Pyhäjärvi exhibited the greatest seasonal warming (+1.34°C per decade for 1-June) due to early spring ice-off in recent years. Pyhäjärvi's July-August trend was significant (+0.61°C per decade); fall trends also increased but not significantly. Konnevesi exhibited significant warming for most seasonal metrics (+0.60°C per decade for July-August). Kevojärvi's only significant trends were July-August and 1-September (+0.43 and +0.56°C per decade). In Mendota, the July-August metric had the same range of temperatures in the 1894-1930 and 1980-2014 eras, but more warm summers have occurred since 1980. While epilimnetic temperatures in the study lakes have generally increased in recent decades, the rate of seasonal warming has not been uniform or steady.

05-O   Meteorological control of physical structure and phytoplankton phenology in a large lake.

Marieke Anna Frassl [1] - Dirk Schlabing [2] - Maria Magdalena Eder [3] - Karl-Otto Rothhaupt [4] - Karsten Rinke [1]

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The phytoplankton spring bloom (PSB) is a cardinal event in temperate lakes. In deep lakes, this event is mainly determined by stratification onset and the importance of climate on stratification and on the PSB has been shown repeatedly. However, it is not a factor 'climate' that is driving the phenology. It is rather the complex interplay between several meteorological variables that act over different and yet unknown time scales. In our study, we aimed at quantifying how different meteorological variables act on stratification and PSB onset timing. Our study site was Lake Constance, a large, monomictic lake, located at the northern edge of the European Alps. We applied a statistical weather generator to produce several hundred meteorological time series. We used these data as input for a hydrodynamic-ecological lake model to estimate the importance of different meteorological variables and to assess on which time scales they are effective. We found that meteorological variability alone caused a large spread in stratification and PSB onset timing, which could not be explained by one meteorological variable alone. Changing air temperature, shortwave radiation and wind speed separately from each other, showed that wind speed had the strongest effect on timing. Despite the different strength of change, also the time scales over which the meteorological variables acted on stratification and PSB onset timing differed. Time scales were rather short for wind speed and longest for shortwave radiation. With our study, we challenge the strong focus on air temperature in climate change studies. Moreover, changes in overall weather situations and the impact of several meteorological variables have to be taken into account. Key words: weather generator, plankton phenology, climate variability, aquatic ecosystem model, wind speed, shortwave radiation.

05-O Securing food in harsh environments needs toughness and adaptation: feeding habits of chironomids in alpine streams. *Georg Niedrist [1] - Marco Cantonati [2] - Leopold Füreder [1]*

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Glacier retreat is the most striking evidence of global change in alpine environments which is expected to alter hydromorphological, physical, chemical, and biological conditions in river ecosystems. Although successions and alterations of benthic invertebrate assemblages have been studied repeatedly, little is known about their functional organisation. In this study we used natural abundant δ^{13}C (carbon) and δ^{15}N (nitrogen), and gut content analyses to identify trophic linkages between potential food sources (total epilithon, the chrysophyte *Hydrurus foetidus*, and filamentous green algae) and *Diamesa* species (Diptera: Chironomidae), which typically dominate these cold river ecosystems. To estimate diet composition and niche width, we employed Bayesian stable isotope mixing models (MixSIAR) and Stable Isotope Bayesian Ellipses (SIBER). As multiple factors are known to shape benthic communities, we investigated trophic feeding habits at sites located along a multifactorial gradient of environmental harshness to simulate environmental change and thus evaluate trophic consequences. One significant outcome of these analyses was that feeding plasticity is mandatory for survival in harsh alpine streams, and suggests that this adaptation is the key to understanding the dominance of *Diamesa* species in cold, high, and dynamic stream habitats.

05-O Shift in planktonic communities in response to man-made eutrophication and global warming in indian ponds. *Jayanthi Muthukumaraswami*

Seethlakshmi Ramaswami College, Bharathidasan University, Tiruchirappalli, India

Small lakes and ponds are the most important and active environments in the earth. Emerging studies show that small water bodies, especially in tropical regions are more active in every process than large lake, terrestrial and marine ecosystems. They are highly productive and in spite of the size, they contribute maximum to the global carbon cycle by sequestering carbon at rates even greater than all the other global ecosystems. But such water bodies are neglected and left uncared by most of the Limnologists. Climate change has profound effects on aquatic systems especially on small ponds which react very fast to the changing climate and the impact is in full intensity. They respond immediately and are reflected in all levels of the food chain, whether it is long or short. Simultaneously increased urbanization, sewage disposal and intensive farming practices have increased the nutrient loading in many water bodies world-wide. This has also resulted in major changes in the biological structure and dynamics of the water body, a change from clear to turbid state. Increased water temperature and eutrophication enhance the process rates and complicate the system functioning resulting in changing the compositions of both phytoplankton and zooplankton community. Effects of eutrophication and global warming on ponds are inseparable and the food web interactions become more complex. Eutrophication directly increases the phytoplankton density thereby altering the water transparency leading to changes in the rest of the trophic levels, while the effect of climatic change also increases the phosphorus level through internal loading. Zooplankton occupies a central position between the autotrophs and heterotrophs and forms an important link in food web of the freshwater ecosystems. Zooplankton are the good indicators of changes in water quality, because they are very sensitive to the external pressures. The shift in planktonic communities may not be due to global warming alone as eutrophication due to human impact also remains as the influencing factor. Hence the present study compares the trend in changes of the planktonic communities over a period of 20 years in small ponds to understand the impact of eutrophication and global warming which might provide a powerful framework to understand the future aquatic systems in the light of forewarned global warming to provide successful ecosystem services and water resources.

05-O Global boom in hydropower dam construction: consequences for freshwater megafauna hot spots. *Christiane Zarfl [1] - Sonja C. Jähnig [2] - Jürgen Berlekamp [3] - Vanessa Bremerich [2] - Fengzhi He [4] - Savrina Carrizo [5] - William Darwall [5] - Klement Tockner [4]*

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Economic development, increasing electricity demand, and mitigation of climate change have stimulated dam building activities globally, especially in emerging economies in Africa, South America and Southeast Asia. Following the COP21, many governments decided to include the expansion of hydropower construction within their Intended Nationally Determined Contributions to address climate change. Thus, we are facing a major boom in hydropower dam construction. Actually, at least 3,700 hydropower dams (> 1 MW) are under construction or planned (Zarfl et al. 2015). Despite the advantages of hydropower technology, it is not a "clean" or "green" electricity source, as frequently claimed. A number of direct and indirect consequences come along with severe social, economic and ecological effects such as relocation of people, trans-boundary conflicts (Richter et al. 2010), fragmentation of river networks (Grill et al. 2015), and changes in the natural flow, thermal and sediment regime (Constantine et al. 2014) that propagate downstream. This causes the loss of habitats, restricts movement of aquatic organisms, and alters or even eliminates biodiversity (Winemiller et al. 2016). The freshwater megafauna, i.e. all fish, reptile and mammal species with an average maximum adult mass of 30 kg or more, is especially susceptible to flow alteration, habitat destruction, and fragmentation. We combined, at the global scale, comprehensive information on future hydropower dams with the contemporary distribution patterns of freshwater megafauna species (http://www.freshwaterplatform.eu). Species distribution data are available for hydrographic spatial units defined as HydroBASINS level 8 (www.hydrosheds.org, Lehner & Grill 2013), which cover a few hundred km^2 each. Based on the results, we identified centres of species richness for freshwater megafauna, and the potential consequences of future hydropower dams to species range. One example is the Salween catchment, which was so far classified as "not affected" by fragmentation. However, high species richness in native freshwater megafauna will be confronted with a high number of hydropower dams in the near future. Our results not only highlight areas in need of immediate attention for the potential impact of dams to freshwater megafauna but also help in raising awareness for the critical status of freshwater biodiversity in general, and may help to set priorities in systematic conservation planning.

05-O   The impact of climate change on mixing patterns of drinking water reservoirs in different regions of Germany.   *Kathrin Jäschke [1] - Tilo Hegewald [2] - Annekatrin Wagner [1] - Thomas U. Berendonk [1] - Lothar Paul [3]*

Institute of Hydrobiology, University of Technology, Dresden, Germany [1] - Landestalsperrenverwaltung Sachsen, Sächsisches Staatsministerium für Umwelt und Landwirtschaft, Pirna, Germany [2] - Ökologische Station Neunzehnhain, University of Technology, Dresden, Germany [3]

Long-term data of the water temperature in the upper layers of German drinking water reservoirs show increasing trends in all months of the year. However, though the temperature trends are regionally quite similar, their consequences for the seasonal mixing and stratification patterns, for the timing of attaining water temperature limits that are relevant for the development of key species and their trophic interactions, and thus for the water quality are depending on the reservoir's geographical position. Generally, iceout tends to occur earlier in dimictic reservoirs or ice is more often missing at all. There is a tendency towards oligomixis in reservoirs that used to be monomictic. While the beginning of summer stratification occurs generally earlier, there is no trend for the end of the summer stagnation due to the strong influence of the reservoir specific withdrawal of raw water for drinking water supply and the release of compensation water from the hypolimnion. Knowledge about the regional consequences of global change is important for planning and adaptation of the future requirements of reservoir management in terms of water quantity and quality.

05-O   Long-term trends in the functional composition of the River Danube phytoplankton.   *András Abonyi [1] - Éva Ács [1] - Gábor Várbíró [2] - Keve T. Kiss [1]*

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Long-term trends in lake phytoplankton are extensively studied, at least in large lakes. In large rivers, however, potamoplankton (river phytoplankton) is still receiving a less pronounced interest. River phytoplankton datasets are mainly based on species level data, which gives limited information about how the community is functioning. Recently,

phytoplankton functional concepts were proved as effective ecological tools also in lotic systems, and may also hold potentials for better understanding long-term data. We analysed trends (1980-2014) in the River Danube potamoplankton together with hydrological and chemical data at the middle river section at Göd, above Budapest (Hungary). We found a decreasing trend in phytoplankton biomass from the 1990s at an accelerating rate. However, functional composition displayed diverse long-term trends. Compositional change in planktonic centric diatoms indicated altered trophic conditions, while trends in biomass contributions between planktonic, meroplanktonic and benthic algal groups indicated fundamentally modified environmental constraints at the middle Danube section. Our results emphasize the benefit of considering functional composition of river phytoplankton in long-term studies, helping the understanding of major effects of global climate change, including altered hydrological, trophic and light conditions.

05-O Are the changes of stream network and periphyton pattern in a high alpine glacier catchment (Rotmoos Valley, Ötztal, Austria) since 2001 driven by climate change? _Eugen Rott_

Institute of Botany, Innsbruck University, Innsbruck, Austria

The 10 km^2 catchment of the Rotmoos valley (RM) situated in Ötztaler Central Alps (Austria) harbors an interesting stream network originating from a central major and a few smaller lateral glacier catchments. It comprises a major river and both glacier-fed and groundwater fed streams. The valley bottom of RM has been intensively studied since longer time concerning effects of glacier retreat on terrestrial biota and concerning lotic insect and bacteria longitudinal differentiation in the main river. It was found to be also suitable to trace global environment change effects on a small scale stream network along warmer and longer summers (=longer ablation periods) in the last years. We recorded sever changes of the valley bottom and thus the whole hydrological network within the RM with considerable changes in runoff of the side streams in the last 15 years (e.g. two out of 14 streams drying out completely). Two larger glacial streams were formed over the opened bedrock of a hanging side glacier and one ground water spring stream originated in the moraines of the retreat area of the central valley glacier.

We hypothesized that species richness and diversity of algae would have increased with higher temperatures especially causing a positive effect on diatoms. Earlier periphyton studies of all streams in the catchment (Rott et al. 2006; Rott, Gesierich & Binder 2010) have shown that glacier fed streams were species poorer than groundwater-fed ones and species richness of diatoms was closely related to the % glaciation of the sub-catchments. The first results showed however that between 2001 and 2015 even for the hydrological stable sites the similarity (Jaccard's Index) of diatom communities was remaining significantly lower in the glacial than in the spring streams. At the same time the changes of species composition and richness of the other algae (cyanobacteria and eukaryotic groups) were also high. We will enter these data obtained from natural pebble substrates into statistical analyses including e.g. multivariate analysis of environmental conditions (physical and chemical water quality, % catchment glaciation) and community type analyses (NMS) to clear up the effect of potential other variables than climate and time on the periphyton pattern.

05-O Reintroduction of type-specific macroinvertebrate fauna into a lowland stream - a resettlement approach. _Arlena Dumeier_ [1] - _Armin Lorenz_ [2] - _Daniel Hering_ [2] - _Ellen Kiel_ [1]

Institut for Biology and Environmental Sience, University Oldenburg, Oldenburg, Germany [1] - *Aquatic Ecology Group, Duesburg - Essen University, Essen, Germany* [2]

A reduction of macroinvertebrate species and communities has occurred in the last decades particularly due to expanding degradation of streams and rivers. The resulting deficits of freshwater ecosystem functioning is aimed to compensate using restoration measures induced by the European Water Framework Directive. Here habitat improvements should lead to a good ecological status.

However, improvements in hydromorphology do not necessarily lead to an increase in type-specific fauna, caused by several recolonization limitations, such as habitat fragmentation by dams or motorways. These impacts might limit or prevent the natural colonization processes, i.e. drift, upstream movement or oviposition. Therefore, fragmented streams often lack typical faunal elements due to minor distribution rates of several species. At stream sections, where the expected recolonization success after years has not occurred, artificial colonization of stream-type specific macroinvertebrate fauna could be a solution.

In this study, we aim to develop a method for a relocation of benthic macroinvertebrate communities, including type-specific species. Macroinvertebrates from a donor stream will be relocated in a recipient stream, which is colonized by

a depleted macroinvertebrate community. For a successful relocation, we want to develop a gentle removal and transport routine of the macroinvertebrate species, in order to keep the stress level of the organisms low.

This talk will give insights in the developed, executed and evaluated method and will present preliminary results. The substrate preferences of the macroinvertebrate fauna will hereby be used by providing natural substrate exposures (NSE). Pretests indicated high colonization numbers of different type-specific macroinvertebrate taxa on several NSE types. The substrate acceptance of the offered NSE and the transport of macroinvertebrates within their NSE enables a translocation with low mortality rates. Further analysis and controls are part of the pilot project and will show if the resettlement approach of macroinvertebrates is successful.

05-O   1D thermodynamic modelling of Lake Maggiore for thermal structure evolution predictions under climate change. _Claudia Dresti_ [1] - _Andrea Fenocchi_ [2]

Institute of Ecosystem Study, CNR, Verbania, Italy [1] - _Department of Civil Engineering And Architecture, University of Pavia, Pavia, Italy_ [2]

The deep subalpine lakes have been characterised during the last decades by an oligomictic behaviour, full overturns being achieved only at the end of cold and windy winters. Since vertical mixing is essential for the chemical and biological dynamics, the study of how such behaviour will evolve with future climate change is strongly relevant.

In order to investigate that on Lake Maggiore, we built a 1D thermodynamic model of the basin using the General Lake Model (GLM) (Hipsey et al., 2014). Calibration was performed reproducing the thermal evolution in the period 1998-2014, feeding the model with meteorological data measured at the Pallanza and Locarno-Monti weather stations and comparing the results against monthly temperature observations along the deepest water column at the Ghiffa limnological site. The availability of extended data series, spanning years with very different meteorological and hydrological features, allowed to obtain calibration coefficients that are less specific and suitable for predictions.

Two versions of the model were initially developed, one with a closed and fixed-level lake approximation and another reproducing the complete hydrological and thermal balances, including inflows, outflow, and direct rainfall contributions. Daily discharges for the major tributaries and the emissary in the calibration period were available, while the daily temperatures of the inflows were computed from daily air temperatures using the _air2stream_ model (Toffolon & Piccolroaz, 2015), calibrated using monthly available observations.

We studied the effects of an evolving climate scenario, with a linear increase of air temperature of 4°C from 2014 to 2081, as predicted by the International Panel for Climate Change (IPCC). A weather generator was used to estimate the corresponding variations of the other meteorological and hydrological parameters in response to the temperature rise, producing multiple series of input data for the thermodynamic simulations, whose results were statistically analysed. This allowed to evaluate the possible evolution of the thermal structure of the lake, especially considering the hypolimnion heating, the trend in the vertical mixing frequency and the influence of the "climatic memory" of the present state over future conditions.

05-O   Is evaluation of large river hydromorphological characteristics using data based on remote sensing and field survey comparable?   _Miha Knehtl_ [1] - _Vesna Petkovska_ [1] - _Gorazd Urbanič_ [1]

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Hydromorphological degradation is one of the main stressors affecting river ecosystems worldwide. Especially large rivers are subject to the strongest pressures, due to their historical role in the development of human society and its dependence on the ecosystem services they provide. In order to achieve sustainable management of river ecosystems, a goal set with the implementation of the Water Framework Directive (WFD), also reliable methods for evaluation of hydromorphological characteristics of large rivers should be developed. In the current Slovenian hydromorphological assessment method (SIHM), morphological characteristics of large rivers are assessed based on 500 m river section field surveys, collecting detailed data on rather local habitat conditions and their modifications. The nature of large rivers, their size and dynamics, would probably acquire assessment of longer river sections, though field surveys would become costlier and more time consuming. As an alternative, remote sensing methods have already proven their usefulness in detecting large river habitat characteristics, especially those of larger scales, and also river dynamics, hardly detectable in the field. The aim of our research is to determine the amount of information on habitat quality and modification parameters of large rivers, that can be obtained with remote sensing, in comparison to field surveys using the SIHM

method. Sites on different types of large rivers with a catchment area between 1000 and 15000 km^2 in Slovenia will be used with the whole gradient of hydromorphological conditions, from natural to severely modified sites. Data on habitat characteristics will be acquired using Geographic information system (GIS) tools, with orthophotos as basic layers. Due to easier detection of particular characteristics, individual river segments will be inspected based on ortophotos taken at the lowest water level. A Spearman's rank correlation test will be applied to test the strength of the relationship between individual SIHM indices obtained using remote sensing and field survey data. Our hypothesis is that SIHM indices, calculated on remote sensing data, will be well related to those, calculated on field gathered data. Moreover, some new morphological parameters (e.g. size of islands, bars, backwaters or amount of sunken woody debris) will be considered in the SIHM indices calculated on remote sensing data. Morphological condition of river stretches with varied surveyed length will be compared (500 m – 5000 m), providing us insight into small to medium scale variability of large rivers morphological conditions. We expect that newly collected morphological data in combination with substantially longer surveyed river stretches (up to 5 km) should give comparable amount of morphological information to 500 m field surveys.

05-O Extreme weather events boost lake ecosystem metabolism: evidence from a large-scale enclosure experiment.   *Darren P. Giling, Jens C. Nejstgaard, Stella A. Berger, Hans-Peter Grossart, Armin Penske, Marén Lentz, Georgiy Kirillin, Peter Casper, Jörg Sareyka, <u>Mark O. Gessner</u>*

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Field observations indicate that extreme weather events can strongly affect lake ecosystems. Storms disrupting thermal stratification and redistributing mineral resources and plankton communities are particularly important. However, rigorous experimental tests of the consequences of exceptional storms on lakes are scarce. Here we present data from a replicated ecosystem-scale manipulation in eight large enclosures (9 m diameter, 20 m depth) in a deep clear-water lake to elucidate how internal restructuring by exceptional storms affects lake metabolism. We experimentally simulated wind-induced disturbance of summer stratification in four of the eight enclosures by lowering the thermocline by 6 m, thus mixing nutrients and deep-water plankton communities into the epilimnion. Depth-integrated rates of gross primary production (GPP) and ecosystem respiration (ER) were modeled with a Bayesian approach based on open-water dissolved oxygen concentrations measured at high spatial (0.5 m depth intervals) and temporal (30 min time intervals) resolution for 6 weeks after the event. Experimental mixing stimulated epilimnetic GPP by an average of 76% above controls over a period of 4 weeks. ER was boosted by an average of 71%, remaining highly coupled to the elevated GPP. However, the entire water column became substantially more autotrophic for > 3 weeks. This conspicuous and protracted stimulation of lake metabolism was primarily driven by an epilimnetic bloom of filamentous cyanobacteria that were carried from a thin metalimnetic layer to the surface water. Overall our results show that short single mixing events can induce prolonged changes in ecosystem metabolism, independent of external organic matter inputs. Consequently, changes in the frequency, severity or timing of extreme events projected under future climatic conditions might be strong enough to outweigh the influence of gradual trends of global environmental change on lakes.

05-O Climate change effects on riparian vegetation communities: a case study in a free flowing river (NW Spain).   *Vanesa Martínez-Fernández [1] - Mijke van Oorschot [2] - <u>Jaco de Smit</u> [2] - Diego García de Jalón [1] - Marta González del Tánago [1] - Tom Buijse [3]*

Department of Natural Systems And Resources, Universidad Politécnica de Madrid, Madrid, Spain [1] - Faculty of Geosciences, Universiteit Utrecht, Utrecht, Netherlands [2] - Department of Freswater Ecology Water Quality, Deltares, Utrecht, Netherlands [3]

Fluvial system components, including riparian vegetation and channel morphology, are mostly structured by the hydrological conditions of the river. Hence, alteration of these hydrological conditions would inevitably lead to changes in river morphology and riparian vegetation. Climate change is an inevitable autonomous event which is going to alter hydrological conditions. Therefore, it is critical to assess the influence of climate change on river ecosystems and find ways to mitigate potential negative effects.
The general assessment of global patterns of climate change predicts an increase of temperature and a decrease in total precipitation in southern Europe; and hydroclimatic models forecast a reduced discharge with higher winter flows and

lower summer flows. These changes in flow conditions are likely to affect stream biota through changes in their life-cycles. The consequences of climate change have been widely studied in relation to macroinvertebrates and fish communities, but the effect on riparian vegetation is less well understood.

Riparian vegetation is not only a biological element of the fluvial ecosystems that remains static under given conditions, but it interacts with morphological processes, generating distinct habitat mosaics and river patterns. In this study we model the interaction between riparian vegetation and morphodynamics under climate change conditions. To this end, we use an innovative model coupling advanced morphodynamics and dynamic vegetation (Van Oorschot et al., 2015). The model was applied in a wandering gravel bed river with a perennial flashy flow regime and mean annual discharge of 4.6 m^3/s. We explore the response of riparian vegetation and river morphology to a changing flow pattern in the context of climate change analyzing the suitability of existing management scenarios to reduce the possible risks of habitat decline.

05-O   Assessing the risks of zinc and silver nanoparticles to amphibians- from laboratory to ecosystem.   *Michael Barry*

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Nanoparticles are molecules with at least one dimension that is less than100 nm. The global value of the nanotechnology is estimated at $27 billion in 2015 and is expected to grow significantly over the next decade. The production of many new types of particles, with novel and poorly understood properties, is a major challenge for environmental protection. In particular, it is important to determine if effects observed in the laboratory can be extrapolated to the natural environment. In this study we measured the lethal and sublethal effects of zinc oxide (ZnO-NP) and silver oxide nanoparticles (AgO-NP) to tadpoles of the Arabian toad (Bufo arabicus), in the laboratory and in microcosm experiments.

In the first set of experiments the effects of three size classes of ZnO (10-30, 80-100 or 200 nm), and one size class of AgO-NPs (10-80 nm) on the survival and growth of tadpoles were measured over 21 days. Nanoparticle concentrations were 0, 5, 10, and 50 mg/L for ZnO and 0, 0.1, 1 and 10 mg/L for AgO. The ZnO-NPs caused significant mortality at all concentrations, whereas the AgO-NPs had no effect on survival, but reduced growth at 10 mg/L.

In the second set of experiments, the effects of NPs on the growth of B. arabicus tadpoles in microcosms was tested. Experiments were performed in 13 L circular tubs in a temperature controlled greenhouse for seven weeks. The microcosms contained a substrate of natural pond sediment. Ten Gosner stage 24 tadpoles were added to each microcosm. The microcosms for the experiment with AgO-NPs also contained leaves of Ficus salicifolia to measure the effects of the NPs on leaf decomposition rates and on the fungal community. Primary production was measured by determining the concentration of chlorophyll a on tiles. ZnO-NPs caused 100% mortality at 50 mg/L and significantly reduced tadpole mass at the lowest concentration of 5 mg/L. There was no effect of Ag-NPs on the survival or growth of tadpoles even at the highest Ag concentration (10 mg/L), and no effect on the rate of leaf decomposition or primary production. AgO-NPs did significantly alter fungal community composition.

The results of this study demonstrate that laboratory studies accurately predicted the toxicity of the ZnO-NPs, but significantly over-estimated the toxicity of AgO-NPs. There is a need to perform studies at multiple scales to accurately assess the risk of nanoparticles.

05-O   The role of multidecadal variability in the Atlantic Ocean for freshwater availability in East Africa, Australia, and the Indian Summer monsoon. *Stefan Liess*

Department of Earth Sciences, University of Minnesota, Minneapolis, United States

The impacts of climate change on regional freshwater availability are expected to be more complex than the "wet regions get wetter – dry regions get drier" hypothesis based on a changed atmospheric circulation with increased condensation from updrafts and decreased condensation from downdrafts. We show how the atmosphere-ocean circulation affects rainfall and thus freshwater availability over East Africa, India, and Australia on decadal time scales. Global data sets of Sea Surface Temperature (SST) and Sea Level Pressure (SLP) for the past 100 years are provided by the Hadley Centre in the United Kingdom. Precipitation data are available from local weather services, the Global Precipitation Climatology Centre (GPCC) and the Climate Research Unit (CRU).

One driver of rainfall over East Africa around the Lake Victoria basin is the Somali jet, a strong low-level wind that transports moisture from the Indian Ocean along the East African coast toward India. However, we found that also the northeastern Atlantic SST related to the ~70-yr period of the Atlantic Multidecadal Oscillation (AMO) is negatively correlated to the East Africa Long Rains during March-April-May. The AMO can be tracked back 8000 years with $\delta^{18}O$ isotope analyses around the Atlantic, thus making it difficult to distinguish between anthropogenic and natural causes for regional freshwater change from shorter climate signals. The recent AMO signal has maxima during the 1930s and 2000s and a minimum during the 1970s. This minimum contributed to the strong shrinking of Lake Chad and a strong Sahel drought in the 1980s. The maxima can not only be related to droughts over East Africa, but also to decadal droughts over Australia, namely the "World War II Drought" and the recent "Millennium Drought". It is expected that the positive AMO phase will dominate in a warming climate, thus promoting a drier climate over East Africa and Australia.

For future projections of freshwater availability, global climate models (GCMs) can be coupled to river transport models. We use the input from these GCMs for downscaling with a regional climate model. These regional results can provide a forecast of future freshwater availability both locally and downstream.

We also observe a positive relationship between AMO and Indian rainfall, especially over the west coast. In a 30x30km simulation with a regional climate model we show that strong westerlies during the monsoon can generate a trough that reaches the tropical Pacific where it generates favorable conditions for typhoon genesis. In a case study, we simulate the occurrence of three typhoons during a strong monsoon trough, including super typhoon Herb, which made landfall in Taiwan and Eastern China in July/August 1996 just 5 day after the region was hit by typhoon Gloria. Thus, the Indian monsoon system can indirectly affect water availability over East Asia. High soil moisture values are a relatively smooth indicator to track remnants of typhoons over land.

05-P   Comparison of benthic macroinvertebrate metrics for the ecological status assessment of rivers from mining areas in Northern Spain.   *Noemi Costas [1], Isabel Pardo [2], Leire Méndez-Fernández [1], Maite Martínez-Madrid [3], Amanda Miranda [4], Cristina Delgado [5], Pilar Rodríguez [1]*

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The present study is part of an ecological risk assessment to metals in the Nalon River basin (N Spain), evaluating invertebrate community responses to different metal exposure routes within a Reference Condition Approach. In the implementation of European Water Framework Directive two approaches to classify ecological status of rivers based on invertebrates have been proposed for this area. The first approach is the type-specific Invertebrate Multimetric index (METI) applying typology "sytem A" used in the intercalibration exercise, and the second is a type-specific invertebrate predictive model (NORTI) designed for specifically assess the ecological status of Northern Spain rivers. Both approaches were applied to a dataset of 14 reference and 16 mining-impacted sites. Our main objective was to check the ability of the two methodologies in use to discriminate metal impacts in rivers within mining areas. The response of different diversity, abundance, percentage and diversity metrics were also evaluated, according to the typologies established for the METI and NORTI approaches. Results showed significant differences between ecological quality ratios (EQR) extracted from METI and NORTI methodologies both for reference/test sites separately and for all sites together, with a general tendency to obtain lower EQR values with NORTI. With METI classification 78.6% reference sites were in "High" ecological status, and only 28.8% when using NORTI, wherewith most sites are in a "Good" status. With regard to the test sites, the percentage of them below "Good" status increased from an 18.8% with METI to a 56.25% with NORTI. On this sense, the differences observed between methodologies may be arising from the ability of NORTI to detect more effectively some pressures such as the effect of metals on invertebrate communities, as this approach is using specific reference communities for the studied area. Only Type RC-3 (METI typology) and Type 4 (NORTI typology) sites showed significant EQR differences between reference and test sites with the two approaches, both with a decreasing EQR pattern on mining areas. When comparing individual community metrics, variations between the invertebrate community structure in reference vs. test sites can also be inferred, mainly regarding the presence and abundance of sensitive taxa, which suggests the existence of species-specific mining-pressure impacts. Trying to elucidate the reasons behind the observed differences the next step in our research will be testing the sensitivity of METI and NORTI

methodologies in detecting stress gradients (including heavy metal values), from a multiple stressor perspective. The possibility of synergic effects due to the cumulative effect of pressures will also be tested.

05-P   Dissolved greenhouse gas concentrations as proxies for emissions: first results from a survey of 43 alpine lakes.   *Sylvie Pighini [1] - Georg Wohlfahrt [2] - Franco Miglietta [3]*

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Up to very recently, freshwater ecosystems were neglected in assessments of the global carbon cycle and considered merely as passive 'pipes' which transport carbon from the land to the oceans. This view has been challenged by an increasing number of studies showing that freshwater ecosystems may negate a substantial fraction of the carbon sink through carbon dioxide (CO_2) and in particular methane (CH_4) emissions and thus rather should be viewed as 'reactors' which process a large fraction of the terrigenous carbon. Most of our knowledge on freshwater CO_2 and CH_4 emissions to date derives from studies in tropical and boreal regions, while temperate freshwater ecosystems are understudied. This study is focused on lakes from the Alpine area and their content in dissolved greenhouse gases, CH_4 and CO_2. We mostly aim to assess the content of dissolved methane and carbon dioxide from the Alpine lakes in order to understand whether Alpine lakes could be potential CH_4 and CO_2 emitters. We also would like to relate concentrations to lake characteristics and potential biotic and abiotic driving forces.
A diverse set of 43 lakes, from Trentino, South Tirol (Italy) and North Tirol (Austria), was selected resulting in a gradient with respect to elevation (from 240 to 1700 m a.s.l.) and latitude (from 45.52° to 47.38°). Complementary to dissolved CH_4 and CO_2 surface water samples, dissolved oxygen and temperature were measured. Only water surface samples were considered. Analyses were done with a gas chromatographer equipped with a flame ionization detector (FID) for CH_4 and a thermal conductivity detector (TCD) for CO_2 determination.
The first results show that all the sampled lakes were super-saturated in dissolved methane and carbon dioxide concentrations, at least partly to a degree that in the literature has been shown to result in substantial emissions to the atmosphere. To estimate emissions, CO_2 and CH_4 fluxes will be quantified using the floating chamber technique on a subset of the investigated lakes in a next step. Results will indicate which parameters lead to greenhouse gases emissions in the Alpine area.

05-P   Phytoplankton response to winter warming modified by large-bodied zooplankton: an experimental microcosm study.   *Hu He [1] - Zhengwen Liu [1] - Erik Jeppesen [2]*

Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, Nanjing, China [1] - Department of Bioscience, Aarhus University, Aarhus, Denmark [2]

While several field investigations have demonstrated significant effects of cool season (winter or spring) warming on phytoplankton development, the role played by large-bodied zooplankton grazers for the responses of phytoplankton to winter warming is ambiguous. We conducted an outdoor experiment to compare the effect of winter warming (heating by 3°C) in combination with presence and absence of *Daphnia* grazing (*D. similis*) on phytoplankton standing crops and community structure under eutrophic conditions. When *Daphnia* were absent, warming was associated with significant increases in phytoplankton biomass and cyanobacterial dominance. In contrast, when *Daphnia* were present, warming effects on phytoplankton dynamics were offset by warming-enhanced grazing, resulting in no significant change in biomass or taxonomic dominance. These results emphasize that large-bodied zooplankton like *Daphnia* spp. may play an important role in modulating the interactions between climate warming and phytoplankton dynamics in nutrient rich lake ecosystems.

05-P   Proteomic analysis of aquatic microbial responses to nanoparticulate and ionic silver.   *Diana Barros, Cláudia Pascoal, Fernanda Cássio*

Centre of Molecular and Environmental Biology, Department of Biology, Univ. of Minho, Braga,

Environmental biomarkers are the most promising next generation risk assessment tools, augmenting measurements of direct and highly sensitive responses at the cellular and sub-cellular levels. Silver nanoparticles (AgNPs) are among the mostly used nanoparticles and likely to be released in significant amounts to aquatic environments. Due to their antimicrobial properties, it is relevant to examine whether AgNPs can pose a risk to aquatic microbes in natural ecosystems. We used a bacterial strain, *Pseudomonas* sp. M1 (PsM1), isolated from sediments in a metal-polluted stream, to gain insights into the molecular mechanisms underlying its ability to deal with the toxic effects of AgNPs using a proteomic approach. We identified changes in the protein expression at AgNP concentrations inhibiting biomass production in 20% (EC_{20}). After SDS-PAGE, the LC-MS/MS identified almost 200 proteins, about 50% of which increased its abundance under stress induced by AgNPs and Ag^+. Silver is known to react with proteins by combining with the thiol groups of enzymes, leading to protein inactivation. After AgNPs exposure, some of the upregulated proteins were associated with the degradation of transiently denatured and unfolded proteins, accumulated in the periplasm under stress conditions (e.g. periplasmic serine endoprotease). Exposure to AgNPs also induced proteins related to stress response, in particular, antioxidant enzymes, such as catalase-peroxidase and superoxide dismutase. The antioxidant response was consistent with our previous work suggesting that the ability to initiate an efficient antioxidant response is essential for the bacterium to cope with AgNP toxicity. We also found an increase in the proteins involved in amino acid (e.g. ornithine carbamoyltransferase) and energy metabolism (e.g. fructose-bisphosphate aldolase), which may reveal an AgNP-induced reorganization of the metabolic fluxes, that is compatible with an increased need of the bacterial cells to generate energy to support the defense mechanisms against AgNPs toxicity. An increased amount of chaperones (e.g. chaperone protein ClpB) was also found. These proteins play an essential role in the cell by assisting the correct folding of nascent and stress accumulated misfolded proteins and preventing their aggregation. AgNPs can likewise interact with elements of bacterial membranes, causing structural changes, dissipation of the proton motive force, which is consistent with the increase in a specific porin with serine protease activity. Overall, PsM1's response to the stress induced by AgNPs involved, among others, stress response proteins, proteins of the energy metabolism and transport proteins. Since the risk of the appearance of bacterial strains with augmented silver resistance is growing, it is highly recommended that the knowledge obtained from PsM1's response to AgNPs be considered in future studies.

05-P   Quantitative weight of evidence approach for hazard evaluation of engineered nanoparticles in freshwaters.   *Arunava Pradhan, Cláudia Pascoal, Fernanda Cássio*

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Release of engineered nanoparticles (ENPs) into natural waters raises concern about risks to aquatic biota and ecosystem functions. Hazard screening of ENPs is a key step for environmental risk assessment (ERA). But the lack of knowledge and complex nature of ENPs in aquatic environment limit the regulatory frameworks. Moreover, unreliable measures induce impaired and inadequate risk assessment of ENPs in freshwaters.
Weight of evidence (WoE) is a useful framework for constructing individual lines of evidence (LoE) to build conclusions on the degree of impairment. WoE frameworks were suggested for ERA of ENPs since conventional approaches had huge limitations. However, most of the WoE frameworks are qualitative lacking transparency.
We applied quantitative WoE approach based on multi-criteria decision analysis (MCDA) as a transparent and scientifically robust decision analytical framework for hazard evaluation of ENPs in freshwaters to integrate heterogeneous information. We used silver nanoparticles (Ag-NPs) as a proxy of ENPs, because Ag-NPs are among the most abundant ENPs seeking ERA. Peer-reviewed articles providing 140 measurement endpoints (LoE) and information on data quality, exposure, properties and toxicity of Ag-NPs (at different biological organization and trophic levels) in freshwaters were used. The WoE established the LoE-specific "hazard index" of Ag-NPs in freshwaters by calculating "hazard score" based on 3 criteria indices: "physicochemical properties", "toxicity" and "data quality" and their aggregation using "weighted sum". The "physicochemical properties" index was composed of 2 sub-criteria indices based on the influence to exposure or effects of Ag-NPs. Each LoE-specific sub-criterion index was further divided into sets of sub-sub-criteria and so on creating a hierarchy. For instance, "influencing effects" was divided to sub-sub-criteria: "purity", "reactivity", "shape", "biosorption/bioaccumulation", "toxic substance in coating" and "ionic fraction" of ENPs. Each index of the last division in this multi-criteria hierarchy consists of classes (alternatives) assigned with discrete value in [0,100] range. For "toxicity" index, 5 hazard classes were assigned. The "Data quality" index was composed of "adequacy", "reliability" and "relevance" which are also divided into sub-sub-criteria and so on. The "data quality" scores were normalized in the scale [0,1] to construct relative weight in the information pool. The "weights" of decision criteria, sub-criteria or alternatives were assigned by a widely used tool, analytical hierarchy process (AHP), based on

quantitative pair-wise comparison matrix followed by normalization to [0,1] range. Tests for inconsistency and uncertainty confirmed the stability of the model. Overall, the WoE framework for hazard assessment of Ag-NPs in freshwaters suggests its potential application for other ENPs.

05-P   Effect of climatic and hydrological conditions on the emergence of stoneflies (Plecoptera, Nemouridae) in an alpine stream (25 years study).   *Maria Leichtfried [1] - Bronislava Janickova [2] - Leopold Fuereder [3] - Ondrej Mikulka [4] - Petr Pyszko [4] - Vladimir Uvira [2]*

Institute for Limnology, University Innsbruck, Mondsee, Austria [1] - Department of Zoology, Palacky University, Olomouc, Czech Republic [2] - Institute for Ecology, Leopold-franzens-university, Innsbruck, Austria [3] - Institute of Environmental Technologies, University of Ostrava, Ostrava, Czech Republic [4]

The success of a new generation on a particular site is dependent on the emergence as a key phase in the aquatic insects' life cycle. Its timing mainly depends on the local climatic and hydrological conditions. This study was initiated within the "Ritrodat-Lunz" project, a research framework for 25 years, in which a wide range of environmental factors of the low order Alpine stream Oberer Seebach in Lunz am See, Lower Austria was monitored. For this study we evaluated samples of emerging stoneflies from two pyramidal traps, one of which was in the permanently submerged part of the river bed and the other one on the bed sediments, which were flooded periodically at elevated water levels. We compared the basic characteristics of emergence (timing, intensity, synchronization, sex ratio) in these two different habitats and their dependence on the actual hydrological and climatic conditions (SET – the sum of effective temperatures). Canonical correspondence analysis (CCA) with stepwise selection, generalized additive models (GAM) and Chi-square tests were used for statistical analysis.

A total of 7989 emerged individuals of 21 nemourid species were caught over 23 years. Both traps contained the same 21 species, whereof 3079 in the permanently flooded trap and 4910 individuals in the periodically flooded trap were recorded. We selected six of the most dominant species: *Amphinemura sulcicollis*, *Nemoura minima*, *N. cinerea*, *N. mortoni*, *Protonemura aubertii* and *P. nitida*. They exhibited an unimodal pattern of emergence. Emergence took place throughout all the year, the highest peak was reached in June. Uneven sex ratios were found in favoure of males for *Protomemura nitida*, while in favoure of females for *Nemoura cinerea*.

Emergence of the dominant species *Nemoura cinerea* began on average on 22 May, when reaching the sum of effective temperatures SET = 484.16 (sd=318.39) in contrast with the species *Amphinemura sulcicollis*. Its emergence started on average on 24 May, when reaching the sum of effective temperatures SET = 473.54 (sd=115.10).

Seasonality (42.9 %, of the explained variability), snow cover (8.7 %), stream temperature (4.2 %) were the variables with the influence on the Nemouridae species composition of emerging individuals. Water depth contributed only 3.9 % to the explained variability. The maximum intensity of emergence was at 6 °C of water temperature and at a water depth of 40 cm. Our long-term analyses of the emergence patterns and characteristics showed, that for nemourid species abiotic factors do not show a significant influence however, seasonality, water level and fluctuation appears to significantly effect emergence timing and intensity.

05-P   Temporal and longitudinal patterns of the macrofauna in the Rio Saldura (South Tyrol, Italy).
Alberto Scotti [1], Roberta Bottarin [1], Ulrike Tappeiner [1, 2]

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Institute of Ecology, University of Innsbruck, Innsbruck, Austria [2]

Climate change and global warming as well as various forms of pollutions pose several questions about the future availability and quality of water resources. Mountain areas, like the Alps are not only particularly sensitive and vulnerable to all sorts of impacts and global changes, but they are highly important for downstream water resources. This increases the significance of small alpine valleys as ideal study sites for analyzing environmental modifications. This study focuses on the effects of temporal and longitudinal dynamics of the melting process on macrobenthos of the Rio Saldura (BZ), a perennial glacier alpine stream (South Tyrol, Italy). The Saldura stream drains one of the driest valleys of the Alps, which represents the ideal condition to focus on effects induced by climate changes. The presence of a glacier within the drainage basin influences the abiotic parameters of the water course (in particular the discharge) over a wide range of time-scales and thus it has fundamental implications for the whole river system. In order to evaluate the

glacier's influence and the longitudinal patterns of macrobenthic assemblage 4 sampling stations at increasing distances from the glacier have been selected (located from 2300 m a.s.l. to 1500 m a.s.l.). The macrobenthic community, sampled from 2013-2015 using a Surber-sampler, has been integrated by hydro-physical parameters in order to correlate community composition, diversity and environmental variables. The results have shown longitudinal as well as seasonal distribution patterns: the increased discharge due to the snowmelt during June and July corresponds to a decrease of faunal density and number of taxa. These first results suggest that the snow- and ice-melting process significantly modifies the composition of stream invertebrates assemblages and highlights the importance of including these aspects in impact studies on climate changes and fresh waters: the understanding of hydroecological relationships seems to be essential for the development of alpine rivers' operative conservation strategies.

05-P   Link of microbial activity with bed sediment heterogeneity and its responds to drying and re-wetting.   *Sanja Zlatanovic[1], Jenny Fabian[2], Katrin Premke[2,3], Michael Mutz[1]*

Department of Freshwater Conservation, BTU-Cottbus Senftenberg, Germany [1]
Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin, Germany [2]
Leibniz Centre for Agricultural Landscape Research (ZALF), Müncheberg, Germany [3]

Sediment structure affects vertical water flux and it is known as key factor controlling streambed metabolism. In experimental streams we investigated the influence of sediment structure on community respiration (CR), net primary production (NPP) and microbial biomass and composition during: an initial 6 week wet period, upon rewetting after 6 weeks of drying, and for 2 weeks post-rewetting. 16 experimental streams contained sediments structured either in an un-patched sand and gravel mixture or alternating patches of un-mixed gravel and sand. During the 6 week wet period, CR and NPP, algal and bacterial biomass were similar among both sediment structures. Diatom biomass dominated over cyanobacteria and green algae. Streambed desiccation stressed and changed the microbial community. Within hours of rewetting, CR recovered while NPP remained low in both sediment structures. Algal biomass was 31% of the biomass before desiccation with predominance of green algae. However, in the post-rewetting period NPP recovered to rates higher than before desiccation and total algal biomass was similar to biomass before drying. Streams with patched sediment recovered only 58% of bacterial biomass prior to desiccation, while streams with un-patched sediments had similar bacterial biomass before and after desiccation. Single drought shifts streams to a short period of net heterotrophic following rewetting. However in the weeks after rewetting streams become autotrophic. These shifts are regardless of sediment structure. Desiccation affects streambed metabolism influencing microbial functions and structure and overrules effects of sediment heterogeneity whereas the recovery after rewetting is linked to streambed heterogeneity.

05-P   Great lakes of Russia: diagnsis and prediction of state of ecosystem under climate changes and antropogenic impacts.   *Nikolai Filatov[1], N. Diansky[3], R. Ibraev[3], T. Viriuchalkina[2]*

Northern water problems institute Karelian Research center RAS, Petrozavodsk [1], Water Problems Institute RAS, Moscow [2], Institute of Numerical mathematic RAS, Moscow [3]

Russia has more than 2.7 million lakes, among them some very large lakes as Baikal, Ladoga and Onego, Caspian Sea-Lake (partly in Russian territory). Among of priorities there is the investigation on the principal causes of fluctuations of water level of lakes, measured from the nineteenth to twenty-first century, and to develop the estimated forecast of its change for the next decades.
On the basis of the analysis of long-term observations, it has been shown that climate warming in the last 30 years was noted in the catchment areas of all considered lakes (Baikal, Ladoga, Onego and the Caspian Sea), as well as the catchment area of the American Great Lakes. The response of the hydrological regime to climate warming differs significantly, depending on the regional characteristics, the influence of anthropogenic factors and size and type of the catchment area. The impact of the global climate change was different for the catchment areas of the Eurasia's lakes. Common to all lakes considered there is an increasing trend of annual surface air temperature over the last 30 years. The level fluctuations of the Ladoga and Onego Lakes are coherent with the exception of the period of the level raise in the Lake Onego in the mid 50-ies of the last century. The differences in the features of the level change are determined by morphometric features of the lakes and their catchments, as well as the nature of the man-made impact.

Thus, for the lakes of both Eurasia and North America there is great uncertainty in reliable forecast of water levels and changes in ecosystems, required for planning the economic activity and for the mitigation of possible regional changes. An approach was developed that allows us to give a full physical explanation of changes in the water level of large lakes, and therefore generate its forecast. It will provide a full-scale study to forecast changes of lake's ecosystems for 10-50 years.

05-P   Climate induced changes of the metalimnion and consequences for the harmful cyanobacterium Planktothrix rubescens.   *Yana Yankova, Jörg Villiger, Jakob Pernthaler, Ferdinand Schanz, Thomas Posch*

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Climate warming impacts Lake Zurich (Switzerland) by increasing surface water temperatures, reducing spring mixing depths and supporting the proliferation of the toxic low-light adapted facultative-metalimnetic cyanobacterium *P. rubescens*. We investigated its habitat changes by determining the spatio-temporal boundaries of the metalimnion subjecting long-term water temperature data (1978-2013, weekly measurements) to low-pass filtering and binary thresholding. A significant preponed shift in onset (17 d) and a longer duration (33 d) of the metalimnion due to increasing temperatures were detected. Furthermore, the metalimnion exhibited a decrease in thickness due to drawdown of the upper boundary by 2.3 meter. Nevertheless, changes in spatio-temporal metalimnion characteristics did not affect the net growth of *P. rubescens* during the months in which it is located in this zone (July-September). This is linked to the fact that the zone of optimal light (neutral buoyancy) conditions still remained within the boundaries of the metalimnion during summer. Moreover, an increase of metalimnetic temperatures in August even positively influenced the cyanobacterial biomass. However, a further drawdown of the upper metalimnetic boundary due to ongoing lake warming might force the cyanobacterium into the turbulent and light oversaturated epilimnetic layer. This might have severe negative consequences for the further development of P. rubescens in the studied ecosystem.

08. BIOGEOCHEMISTRY AND ECOLOGY OF INLAND WATERS

08-O   Long-term chemical changes in Mirror Lake, New Hampshire, USA.   _Gene E. Likens_

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Extreme dilution trends since ~1970 have been reported in bulk precipitation and headwater streams of the Hubbard Brook Valley. Similar declines (e.g. hydrogen ion, sulfate, calcium and magnesium) were observed in Mirror Lake, New Hampshire, USA, located at the base of the Hubbard Brook Valley. Overall, however, the total ionic composition of Mirror Lake has not declined markedly as concentrations of sodium and chloride have increased since ~1970 because of large inputs of salt (NaCl), applied to adjacent roads during winter. Long-term changes in Mirror Lake chemistry initially inferred from sediment cores, and now from measured values since 1967 will be presented. The chemistry has changed from calcium bicarbonate domination after the glacier receded ~14,000 years ago, to calcium sulfate during the 1970s-1980s from acid rain inputs, to calcium-sodium chloride currently. Volume-weighted concentrations for Mirror Lake are available from 1980 to 2011.

08-O   Biogeochemical and microbiological features of the largest arctic river: the Yenisei River.
Michail Gladyshev [1] - Olesia Kolmakova [1] - Alexander Tolomeev [1] - Olesia Anishchenko [1] - Olesia Makhutova [1] - Anzhelika Kolmakova [1] - Elena Kravchuk [1] - Larisa Glushchenko [2] - Vladimir Kolmakov [1] - Nadezhda Sushchik [2]

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In the Yenisei River section of ~1800 biogeochemical and microbiological characteristics were studied, including ecosystem respiration (R), gross and net primary production (GPP and NPP), concentrations of organic carbon and nitrogen, fatty acids (FA), stable isotope ratios, and species composition of bacterioplankton by the method of next generation sequencing (NGS). Based on FA composition of particulate organic matter (POM), for sections of the river were differentiated. Section 1, situated in the upper part of the river, in the Yeniseiskii Kryage mountains, appeared to be a source (GPP>R) of high quality autochthonous organic matter, produced primarily by diatoms and consumed by bacteria of genius _Agrobacterium_. Section 2, situated in middle stream of the river in plain taiga, was a sink (R>GPP) of allochthonous and autochthonous organic matter, produced primarily by cyanobacteria and green algae. Section 3 (middle stream), was primarily a sink (R>NPP) of allochthonous organic matter, consumed by specialized bacteria of genius _Acinetobacter_ and family Oxalobacteraceae. Section 4 (lower stream, forest tundra and tundra), appeared to be a "neutral pipe" for recalcitrant allochthonous organic matter, but also a source of diatom-produced autochthonous organic matter (R ≈ 0, NPP>0). Biogeochemical traits of the sections of the Yenisei River evidently determined dominant species composition of bacterioplankton. Thus, the studied span of the Yenisei River ecosystem represented a mosaic of autotrophic and heterotrophic sections in conjunction with the "neutral pipe" for autochthonous recalcitrant organic matter.

08-O   Shallow water zones are the major sources of methane emissions from lakes.   _Jorge Miguel Encinas Fernández,- Hilmar Hofmann, Frank Peeters_

University of Konstanz, Konstanz, Germany

Estimates of global methane emissions from lakes and the contributions of different pathways are currently under debate. In situ methanogenesis linked to algae growth was recently suggested to be the major source of methane (CH_4) fluxes from aquatic systems. We analysed and compared the spatial distribution of dissolved methane during three years within six lakes with different surface areas and maximum water depths. The data demonstrate that the shallow

water zones are the most likely source of the basin-wide mean CH_4 concentrations in the surface water of lakes. The diffusive methane emissions from lakes should therefore be linked to the methane coming from littoral sediments rather than from in-situ production. This conclusion is also supported by the comparison of the mean of dissolved methane concentration and the mean of the Chlorophyll-a in the surface of three lakes. The seasonal development of Chlorophyll-a and CH_4 concentration is not necessarily correlated and therefore does not support a close link between CH_4 production and phytoplankton biomass.

08-O   Pulsed release of nutrients from organic matter accumulated in intermittent rivers – a global comparison.

Oleksandra Shumilova [1] - *Thibault Datry* [2] - *Joerg Gelbrecht* [1] - *Daniel von Schiller* [3] - *Arnaud Foulquier* [4] - *Roland Corti* [1] - *Klement Tockner* [1] - *Dominik Zak* [1] - *Christiane Zarfl* [5]

Leibniz-institute of Freshwater Ecology And Inland Fisheries (IGB), Freie Universitaet Berlin, Institute of Biology, Berlin, Germany [1] - *National Research Institute of Science And Technology For Environment And Agriculture (Irstea), Lyon, France* [2] - *University of the Basque Country, Bilbao, Spain* [3] - *Laboratoire D'ecologie Alpine, Joseph Fourier University, Grenoble, France* [4] - *Eberhard Karls Universitaet Tuebingen, Center For Applied Geosciences, Tuebingen, Germany* [5]

More than half the channel length of the world's river network ceases to flow at some period of the year. These intermittent rivers (IRs) are increasing in spatial extent and duration of surface drying due to climatic change, water abstraction, and land use change (Acuña et al. 2014, Datry et al. 2014).

During the dry period, IRs accummulate organic material such as leaves, woody debris and algae mats at the surface of the riverbed. After first flush events, large amounts of organic matter (OM) and nutrients are released causing eutrophication and oxygen depletion (e.g. Corti & Datry 2012). Hence, IRs are considered punctuated longitudinal biogeochemical reactors with "hot spots" (e.g. accumulations of coarse particulate OM (CPOM)) and "hot moments" (e.g. rewetting events) (Larned et al. 2010). The current exclusion of IRs leads to inaccuracies in predicting the spatial and temporal dynamics of nutrient and OM fluxes at the catchment scale and globally (Datry et al. 2014).

The aim of this cross-continental and cross-climate comparison is to quantify the accumulation of CPOM in IRs during the dry period and the subsequent leaching of nutrients and OM from CPOM and bed sediments during the first flush events.

The laboratory experiments were conducted within the framework of the international initiative "The 1000 Intermittent Rivers Project" (http://1000_intermittent_rivers_project.irstea.fr). Samples of sediments and CPOM were collected consistently at the end of the dry period from 120 intermittent reaches across 22 countries spanning a wide range of conditions (e.g. climate, vegetation, land use). Leaching experiments were conducted under controlled laboratory conditions (room temperature ($20\pm2°C$), 24 hours leaching) using a weak salt solution (NaCl, 200 mg/L). Leachates were analyzed for nutrients and OM that are readily bioavailable for plant and microbial utilization, in particular dissolved organic carbon (DOC), ammonium (NH_4^+), nitrate (NO_3^-) and soluble reactive phosphorus (PO_4^{3-}). Dissolved OM (DOM) was analyzed by fractionation into 3 major sub-fractions (biopolymers, humic-like substances and low-molecular weight substances) using size-exclusion chromatography (SEC). SEC was also used to measure specific ultraviolet absorbance of the samples at wavelength 254 nm ($SUVA_{254}$) as an indicator of aromaticity.

The first results reflect the effects of i) substrate quality, ii) the duration of the dry period and iii) the landscape setting for nutrient and OM release. Based on the results, calculations of nutrient and OM loads of IRs along individual streams and across catchments are made.

08-O   Carbon cycling and carbon dioxide dynamics during ice-cover period in great Lake Onego, Russia.

Natacha Pasche [1] - *Sebastian Sobek* [2] - *Carsten J. Schubert* [3] - *Beat Müller* [3] - *Hilmar Hofmann* [4] - *Petr A. Lozovik* [5] - *Life Under Ice Scientific Team* [1]

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The Great European Lake Onego provides important resources for Northern Russia. This lake is ice-covered during 5 months in winter. However, very few data are available for winter, as most studies covered the ice-free period. Actually,

comprehension of seasonally ice-covered large lakes is limited compared to the knowledge available from small subpolar lakes or perennially ice-covered polar lakes. To tackle this issue, an international consortium of scientists has gathered around the project « life under ice » to investigate physical, chemical and biogeochemical changes during winter in Lake Onego. As part of this multidisciplinary project, our research focused on carbon dioxide (CO_2) dynamics and CO_2 sources during ice-covered period and during ice break-off. Our main hypothesis is that CO_2 accumulates throughout the ice-covered period, mainly due to blocked gas exchange, the degradation of organic matter (OM) in the sediment, and direct inputs from the inflowing River Shuya.

CO_2 dynamics were measured in Petrozavodsk Bay using a mooring that was equipped with two CO_2 sensors at 3 m and 25 m depth from March to May 2015. Vertical profiles of CO_2, methane (CH_4), dissolved organic and inorganic carbon were collected with water samples at different locations. The main results showed that Lake Onego was slightly over-saturated regarding CO_2, while CH_4 concentrations were extremely low. At 3 m depth, CO_2 increased under the ice at a linear rate of 9.6 ppm/day. During the ice-covered period, CO_2 accumulated four times more in the bottom boundary layer than in the mixed convection layer. This bottom boundary layer might indicate a quantifiable flux of CO_2 from the sediment due to mineralization of settling organic matter (OM).

OM mineralization in the sediment was assessed through sediment cores. According to CH_4 sediment pore water profiles, about 70% of CH_4 was oxidized at 7 cm below the sediment water interface. The total oxidation rate of methane in the sediment was estimated to -2.26 ± 0.22 mgC m^{-2}d^{-1}. In contrast, OM mineralisation rates in the water were shown to be extremely low in this oligotrophic system. This mineralization in the water originated mostly from autochthonous OM, while only a few percent stemmed from the abundant allochthonous OM. Lastly, River Shuya contributes significantly to the dissolved CO_2 of Petrozavodsk Bay, as it represents 93% of the water inputs into the bay and riverine CO_2 concentrations were 2.4 higher than in the bay water.

In conclusion, this study contributes to better understand how CO_2 accumulates under ice in large seasonally ice-covered lakes, and helps to predict how CO_2 fluxes might be modified as a result of climate-driven changes.

08-O   Metrics of organic matter in the European Union lake monitoring.   *Margot Sepp, Toomas Kõiv, Peeter Nõges, Tiina Nõges*

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Organic matter (OM) has numerous geochemical and ecological functions in inland waters (e.g. light absorption, carbon cycling, interactions with metals and organic contaminants) and can affect water quality. Its content has been increasing in surface waters of the Northern Hemisphere and is expected to increase onward due to decreased atmospheric acid deposition and changes in climate and land cover. Organic substances have complex molecular composition and their determination is thus complicated. Aquatic OM is measured with many different methods as no single analytical tool can provide definitive structural or functional information about it. However, metrics of OM are not always a part of monitoring programme, which makes exploring the changes of OM in lakes over the last decades difficult. In the European Union (EU) Water Framework Directive (WFD), metrics of OM are not mandatory physico-chemical parameters, but only recommended parameters for transparency, oxygenation conditions or acidification status. The amount of OM in lakes is monitored under the WFD in 21 European countries, applied parameters are biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC) or dissolved organic carbon (DOC), absorbance, and water colour. Most often used methods BOD, COD, and TOC or DOC determine mainly the content of OM but do not give any information about its structure, composition or origin. At present, no method is applied in lake monitoring programmes of all EU member states and some member states do not monitor OM in lakes at all. Monitoring programmes should include methods that determine the properties of OM (e.g. absorbance or fluorescence spectroscopy) in addition to methods that measure its content (e.g. COD, TOC). Reliable measurement of OM is necessary to obtain an integrated view on the distribution and availability of OM in lakes and to investigate its response to climate change and the overall effect on the global carbon cycle.

08-O   Mechanisms of the algal blooms in the Three Gorges Reservoir, China.   *Lei Zhang [1] - Chuan Zhou [1] - Zhiqiang Xia [2] - Hamilton Paul [3] - Philippe Van Cappellen [4] - G. Douglas Haffner [2]*

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Three surveys on different spatial scales were implemented in the Three Gorges Reservoir to investigate the factors determining the location, timing and size of harmful algal blooms. A broad scale survey of the reservoir and 22 tributaries revealed that although there were minor differences in nutrient concentrations and the Trophic Level Index, algal blooms were confined mainly to backwater areas in the upper reaches of the tributary. A meso-scale survey, along the entire reach of a single tributary (the Pengxi River), confirmed that the bloom developed mainly in the backwater lake (Lake Gaoyang) despite high nutrient levels of N and P throughout the entire length of the river. A comparison between Pengxi River and nearby river, Modao River confirmed that water sections where the tributaries incoming water meets the backwater from Yangtze mainstream are the sites experiencing intense algal biomass accumulation in the tributaries. DNA throughput-environmental factors diagrams revealed that within a single algal bloom event temperature, dissolved total phosphorus, DO and turbidity were the main factors driving the relative abundance of prokaryotic and eukaryotic genera spatially and temporarily.

A small scale, high temporal frequency study in Lake Gaoyang demonstrated that the algal bloom was initiated with the onset of thermal stratification, and ended with the subsequent increase in water levels when the dam began to store water. The latter two studies revealed an unusual thermal structure throughout the tributary that persisted for most the year such that there is no mixed upper layer (epilimion), thus algal blooms were contained in an upper layer of strong density gradients with low light penetration. It is concluded that the Trophic Level Index approach used to identify eutrophication issues in China is not applicable for the water management in TGR where physical processes regulate the location and timing of harmful algal blooms. Although it is possible to manage the development of algal blooms by modifying these physical processes by changing water storage patterns, this effect will be minimal in the backwater areas as a result of the slow response times.

08-O   Does nitrogen fixation by cyanobacteria matter in freshwaters?   *Claudia Wiedner, Andrew Dolman, Sebastian Kolzau, Matthias Knie, Jacqueline Rücker*

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Analysis of data from more than 300 German lakes indicates that not only phosphorus but also nitrogen is a crucial factor determining phytoplankton biomass in many lakes and therefore, efforts to reduce nitrogen input might be meaningful. However, it is often argued that N_2-fixing cyanobacteria could render those efforts ineffective if they compensate for N-deficiency.

The aim of our study was to contribute to a better understanding of Nostocales occurrence and their impact on nitrogen load by nitrogen fixation into freshwaters.

Therefore, we analyzed lake type specific and seasonal distribution of Nostocales biovolume in a set of 350 lakes, analyzed literature data on N_2-Fixation by Nostocales and estimated lake type specific and seasonal N_2-Fixation of Nostocales. Additionally we measured seasonal variability of N_2-fixation in two shallow polymictic lakes and carried out a mesocosm experiment to evaluate the potential of Nostocales to compensate for N-deficiency.

We found that biovolume of Nostocales is of minor importance compared to other cyanobacteria and eukaryotic phytoplankton in all lake types. Median nitrogen input by N_2-Fixation varied from 1-8 mg N $m^{-2}d^{-1}$ between lake types. In the studied lakes, N_2-fixation rates accounted between 3% (mean) to 13% (max.) on total N-Load. The mesocosm experiment showed that Nostocales can compensate 3.8% of the reduced nitrogen input at their median biovolume and up to 23% at their highest biovolume.

In summary we found that on average Nostocales contribution to lake nitrogen budget is small.

08-O   Effects of whole-lake inorganic N enrichment on phytoplankton community composition in northern boreal lakes with low N deposition.   *Anne Deininger, Carolyn Faithfull, Jan Karlsson, Ann-Kristin Bergström*

Department of Ecology and Environmental Science, Umeå University, Umeå, Sweden

Anthropogenic nitrogen (N) deposition has increased N concentrations leading to enhanced phytoplankton biomass in northern hemisphere lakes. However, few studies have assessed how phytoplankton community compositions in N limited lakes are affected by increased inorganic N availability. In this study, we monitored changes in phytoplankton

community composition in response to whole-lake inorganic N addition in a set-up of northern boreal Swedish lakes. Three control and three N-enriched lakes covering a natural gradient in dissolved organic carbon concentration (DOC) were studied over three years with one reference year (2011) and two impact years (2012, 2013). We found that phytoplankton community composition changed in response to fertilization in all lakes. Cyanobacteria were especially favored by N-addition at low DOC, Chlorophyceae and Chrysophyceae at medium DOC, and Cryptophyceae at high DOC levels. Thus, our results suggest that enhanced inorganic N availability induces community composition shifts in phytoplankton, but with different responses along the DOC gradient. This may have implications for zooplankton development, not only by affecting resource quantities, but also quality, with higher proportions of edible and PUFA rich species responding in the DOC rich lakes than in the medium and low DOC lake.

08-O   Hydrological contraction and expansion dynamics drive carbon emissions from a mediterranean fluvial network. *Lluís Gómez Gener*

Universitat de Barcelona, Barcelona, Spain

It is now widely accepted that inland waters are significant sources of carbon dioxide (CO_2) and methane (CH_4) to the atmosphere. However, the sensitivity of carbon (C) emissions to hydromorphological alterations and climate change is still largely undefined. This is especially marked in arid and semiarid regions such as the Mediterranean, which are subject to intensive damming and extreme hydrological fluctuations. Our aim was to understand how hydrological contraction and expansion dynamics shape the magnitude and controls of C emissions in a Mediterranean river network largely affected by damming. We sampled several lotic and lentic segments across the river network during a whole year, with special focus on extreme hydrological events (i.e. floods and droughts). Our results stress the importance of floods and droughts as hot moments for C emissions. During floods, a prominent role of the physical turbulence as a factor enhancing the exchange process between generated and emitted C was detected, highlighting thus lotic systems as hot spots for C emissions. In contrast, the reduction of river flow during drought prolonged water residence times and enhanced the role of in-stream processes (i.e. internal metabolism) in controlling the C efflux. Therefore, during drought, systems with higher residence time become hotspots for C processing, with peaking CH_4 emissions and bacterial activity. Likewise, dry riverbeds in temporary rivers, a widely extended but traditionally neglected habitat of Mediterranean river networks during summer, become hotspots for CO_2 emissions. Our results also suggest that the sources of the emitted CO_2 shifted along the annual hydrological cycle. CO_2 emissions at high flow periods were dominated by inorganic carbon imported from the catchment (i.e. from respiration in soils and rock weathering), while CO_2 produced within the river fuelled emissions at low flow moments as well as in dry riverbeds. Overall, our results indicate that C emissions are a complex but fundamental biogeochemical component of C balances in fluvial networks, and stress its sensitivity to hydromorphological alterations induced by human activities and climate change.

08-O   Carbon budgets, biological processes, and influencing factors in saline shallow lakes of Central Spain.   *Anna C. Santamans, Antonio Picazo, Carlos Rochera, Antonio Camacho*

Cavanilles Institute for Biodiversity and Evolutionary Biology, University of Valencia, Burjassot, Spain

Wetlands are capable to store high amounts of carbon due to their high productivity and the anoxic conditions found in the sediment that difficult organic matter mineralization. However, these anoxic conditions are also a suitable environment for methanogenesis, leading to the production of methane as a result of this anaerobic respiration. This study is focused on the evaluation of the carbon budget of five saline shallow lake located in central Spain selected as model study lakes, as well as to reveal the effect of the main environmental variables, such as salinity, length of the flooding period, temperature and nutrient status on photosynthesis, aerobic respiration and methanogenesis.
Our results show that some physical, chemical and metabolic characteristics of the lakes are among the main factors that determine the carbon balance. The activity of the metabolic processes decreased along the salinity gradient. Furthermore, in less saline lakes helophytes appeared playing a key role on the C-capturing, resulting in these lakes being net carbon sinks. Temperature, given the different Q10 values of the different metabolic processes, is also a very important variable in determining the carbon budget. Experimentally, we have demonstrated a strong activation of methanogenesis with temperature, with Q10 values varying from 2 to 5. Other factors, such as nutrient availability also played an important role, affecting the metabolic processes. All the variables interact and synergistic and antagonistic effects were established. To calculate the carbon balance C-released by aerobic respiration and methanogenesis was

taken to the carbon captured by the photosynthesis. However, given the high pH of the lakes, most of the CO_2 released to water by aerobic respiration turns to bicarbonate, which is not released to the atmosphere, and also to carbonate, which has lower solubility and chemically precipitates. Consequently, only a small fraction of the CO_2 produced by aerobic respiration would actually diffuse to the atmosphere, and instead an important part can also be sequestered as insoluble chemical species. This chemical precipitation, added to the carbon capture in organic matter that accumulates in the sediments, highlights the role of saline Mediterranean lakes as potential carbon sinks.

08-O   Partitioning of metabolism during managed inundation in the floodplain of lower River Murray, South Australia.   *Sanjina Upadhyay* [1] *- Roderick Oliver* [2] *- Kane Aldridge* [1] *- Todd Wallace* [1] *- Justin Brookes* [1]

Water Research Centre, The University of Adelaide, Adelaide, Australia [1] *- Land And Water Flagship, CSIRO, Urrbrae, Australia* [2]

Riverine ecosystems obtain energy primarily through two pathways: (i) internal production by autotrophic organisms, and (ii) via the microbial loop that utilizes terrestrially supplied dissolved organic carbon (DOC) as a basal energy source. The relative importance of these sources of carbon to the aquatic food webs may vary, depending on seasons, degree of flow, and connectivity with the upstream reaches and the surrounding floodplain, as proposed by different conceptual models for river-floodplain systems. Ecosystem metabolism, which incorporates photosynthesis by autotrophs and respiration by autotrophs and heterotrophs, plays a major role in regulating basal food resources that supports upper-level consumers. Since photosynthesis and respiration are primary drivers of dissolved oxygen (DO) dynamics in rivers, tracking changes in DO concentrations provides effective measure of the rate at which energy is produced and made available to the higher order organisms. However, despite a long history of study, our understanding of the sources of carbon fuelling aquatic metabolism under different hydrological conditions, and the contributions of different biotic components to the river ecosystem metabolism is poorly understood.

In September 2014, an extensive Chowilla floodplain of lower River Murray was artificially inundated using a newly installed environmental flow regulator. We estimated and compared metabolic rates of various riverine organisms with the whole ecosystem metabolism before, during and after managed inundation to partition the metabolism of different biota, in order to assess their contribution to the whole ecosystem metabolism. We observed similar whole ecosystem metabolic rates prior to and during inundation periods, and the planktonic metabolic rates were comparable to the whole ecosystem metabolism. Partitioning of metabolism showed that phytoplankton contributed almost 80% (±4%) to the whole system production, with average production rate (±SE) of 2.40 (±0.65) $gO_2/m^2/d$. Furthermore, phytoplankton and planktonic bacterial respiration (±SE) averaged 2.35 (±0.15) $gO_2/m^2/d$, accounting for almost 85% (±4%) of the whole system respiration; while the contribution by zooplankton, invertebrates and fish was less significant. Our results suggest that phytoplankton and planktonic bacteria were primarily responsible for the observed carbon flux within the system. Based on our findings, phytoplankton appear to be a critical energy source to riverine ecosystems even during floodplain inundation, when terrestrial supply of carbon is expected to play a major role in supporting aquatic food webs.

08-O   Dissolved organic carbon in Missouri reservoirs: an analysis of statewide patterns. *Jack Jones, Daniel Obrecht*

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Empirical relations of dissolved organic carbon (DOC) with plant nutrients, catchment features, morphology and hydrology were evaluated for Missouri reservoirs; this ecotonal region includes the transition between the Great Plains in the north and forested Ozark Highlands in the south. Among 203 reservoirs, with data from 5 to 10 summer seasons, DOC averaged 6.4 mg/L with mean values in individual reservoirs ranging from 1.6 to 11.2 mg/L. These concentrations span the lower half of the range for lakes worldwide, with averages greater in the Plains (7.1 mg/L, n=154) than the Ozarks (4.3 mg/L, n=49). Fifteen Plains reservoirs sampled weekly for a year had mean DOC of 6.5 mg/L with averages of 7.0 mg/L during summer and 6.3 mg/L during other seasons. Similarly, 658 consecutive daily samples of DOC from a reservoir in the center of the state averaged 3.7 mg/L, with summer samples averaging 4.0 mg/L. These findings suggest summer sampling likely encompasses a modest annual peak in DOC. Among 40 intensively sampled reservoirs the mean

coefficient of variation for DOC (20%) was less than total phosphorus (40%), volatile suspended solids (48%) and chlorophyll (63%) and most similar to total nitrogen (29%). In the reservoir sampled daily, most changes in DOC from one day to the next were modest; in some 70% of the comparisons the absolute difference was less than 5% of the mean. These findings suggest moderate temporal variation in DOC relative to metrics used to characterize lake trophic state. Across reservoirs located statewide, DOC was more strongly correlated with total nitrogen (log transformed data, r=0.81, n=203) than total phosphorus, algal chlorophyll, or volatile suspended solids (r=0.64 to 0.66). Regression analyses showed 68% of cross-system variation in DOC (log transformed) was explained by latitude and % crop in the watershed (both positive coefficients) along with reservoir depth and the ratio of the watershed-to-reservoir surface area (both negative coefficients). Latitude is negatively correlated with both watershed permeability (r=-0.76) and annual runoff (r=-0.92) and each of these metrics provided similar explanations in regression models. In some models longitude entered to signal a general decline in reservoir DOC from west to east (r =-0.36). Regression analyses based on trophic state metrics showed total nitrogen and algal chlorophyll accounted for 71% of variation among these reservoirs statewide.

08-O   Assessing seasonal food web complexity and topology in a subtropical coastal-lake.

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Food web models provide a useful tool to assess the organization and complexity of natural communities. We condensed an 8-year dataset to examine changes in the diversity and food web properties (complexity and topology) of a sub-tropical coastal lagoon community, and their relationship with environmental variables, over an idealised time series for an averaged year. Phytoplankton, zooplankton, invertebrates and fish were mostly resolved to species level and a large number of environmental variables was recorded. Our results showed that both the number of links and link-density exhibited a wide range of variation that seemed to follow an annual sequence. The temporal organization of the community, based on complexity, follows a hierarchical clustering between two groups of months during the year (grouped here as summer and winter seasons). Furthermore, of all the environmental variables and diversity values (vectors) fitted, the littoral alkalinity, water temperature (both pelagic and littoral), oxygen concentration (both pelagic and littoral) zooplankton diversity, macroinvertebrates diversity and fish diversity showed a seasonal gradient that was highly correlated with the cluster. This pattern was also clearly reflected by the topological similarity of the community between seasons (based on web link pattern and identity). There was a great number of links that appeared and disappeared during the year, while a part of the food web remained stable during the whole period.

08-O   "Every disadvantage has its advantage" (J. Cruijff) – floating mats of the most noxious aquatic weed of the world, water hyacinth, serve as a strong greenhouse gas sink.

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Known as one of the most important nuisance weeds of the world, extensive floating mats of Water hyacinth (*Eichhornia crassipes*) are present in many tropical and subtropical wetlands and lakes, causing significant ecological, economic and societal problems. Being so numerous, they can be expected to have substantial consequences for greenhouse gas (GHG) emissions. Their fast growth sequesters large amounts of CO_2, but simultaneously generates high amounts of organic matter and limits oxygen penetration into the water column, creating favourable conditions for methanogenesis. Root-associated methanotrophs may, however, limit potentially large CH_4 emissions. The balance between CH_4 emissions and CO_2 uptake finally determines the role of the vegetation as a GHG source or sink, but is unknown. To unravel the impact of floating *E. crassipes* vegetation on GHG fluxes, we performed an extensive fieldwork

study encompassing 36 sites in Pantanal and Amazon areas of Brazil. Nocturnal and diurnal water-atmosphere fluxes of CH_4 and CO_2 were measured inside and outside vegetation mats using a floating chamber for diffusive, and inverted funnels for ebullitive fluxes. Emissions of CH_4 to the atmosphere from Water hyacinth mats were, on average, 24% higher than from open waters, but the fluxes varied strongly among sites and included both higher and lower CH_4 emissions from the mats. Total diffusive CH_4 fluxes amounted to 0.56-3548 mg C m^{-2} day^{-1} inside, and 0.43-1496 mg C m^{-2} day^{-1} outside the mats. CH_4 ebullition values were similar inside and outside the vegetation, and varied between 0.03 and 827 mg C m^{-2} day^{-1} inside and between 0 and 972 mg C m^{-2} day^{-1} outside the mats. However, when taking the plants' CO_2 sequestration rates into account and accounting for the 34 times higher Global Warming Potential of CH_4, the total budget indicated that the vegetation acts as a strong GHG sink, taking up around 11 g CO_{2eq} m^{-2} day^{-1}, while open waters emitted around 22 g CO_{2eq} m^{-2} day^{-1}. Our study demonstrates that Water hyacinth vegetation indeed has a great impact on GHG fluxes from wetlands, which should be taken into account when making emission estimates for tropical and subtropical waters.

08-O   Using high-frequency measurements of carbon dioxide or dissolved oxygen for assessing depth-integrated lake metabolism: what are the differences?   *Alo Laas [1] - Biel Obrador [2] - Fabien Cremona [1] - Rafael Marcè [3]*

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Using automated monitoring buoys enabled us to measure continuous day-to-day variation of dissolved oxygen (DO) and CO_2 in Estonian lakes. Data was collected in the summer at up to four different depths in all 8 Estonian lake types, according to European Water Framework Directive. Measurements were done at two depths in fully mixed lakes and at four depths in stratified lakes (two in epilimnion, one in metalimnion, one in hypolimnion). 10 to 30 minute measurements of DO and CO_2 differed largely between lakes.

Gas dynamics were strongly related to diel dynamics of lake metabolism in Lake Valguta Mustjärv and in large Lake Peipsi and, to a lesser extent in coastal lake Mullutu Suurlaht. Among all lakes, Lake Peipsi had by far the lowest CO_2 content in the bottom layers (min 667 µatm), which turned the bottom of Lake Peipsi slightly supersaturated (167%) by CO_2 for that period. The highest concentration of dissolved CO_2 was measured at the bottom of lake Erastvere (31628 µatm), followed by that in coastal Lake Mullutu Suurlaht (19950 µatm). All lakes investigated had at least a short-term stratification regarding dissolved CO_2 while the 4 shallower lakes the concentrations were temporarily fully uniform. Comparing the upper mixed layer gas saturation levels of studied lakes, we can assume that according to DO saturation four lakes act as autotrophic waterbodies and four other lakes are unknown (can vary between auto- or heterotrophic status). According to CO2 saturation three lakes act more as autotrophic and two lakes more as heterotrophic waterbodies while three lakes stay unknown. To consider surface saturation of both measured gases we can assume that four lakes are autotrophic one lake is heterotrophic and three lakes status stays unknown. Our modelling results will show how the depth-integrated estimations of metabolism will define the real metabolic status of those lakes.

08-O   Rocking seiches and sediment dancers: effects on sediment oxygen uptake and porewater chemistry.   *Lee Bryant [1] - Andreas Brand [2] - Alfred Wüest [2] - Georgiy Kirillin [3] - Christof Engelhardt [3] - Hans-Peter Grossart [3]*

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The vertical distribution of dissolved oxygen (O_2) across the sediment-water interface in freshwater systems is frequently controlled by diffusion of O_2 into the sediment from the overlying water. However, advection and bioturbation are often overlooked transport mechanisms in silty sediment and may have significant influence on the extent of the sediment oxic zone and porewater geochemistry. We performed a week-long study during August 2012 in Lake Stechlin (near Berlin, Germany) which is known for strong periodic seiching; additionally, while bioturbation effects have not previously been actively studied in Lake Stechlin, high levels of bioturbation have been observed in

neighboring lakes. Our goal for the study was to primarily focus on the influence of seiching on sediment oxygen and redox dynamics. Using in-situ microprofiler and current velocity measurements, we assessed sediment O_2 uptake in Lake Stechlin and initially anticipated diffusion to dominate O_2 transport into the primarily silty sediment. According to our microprofile data, diffusion-controlled O_2 transport did occur periodically; however, we also observed considerable periodic advective and/or bioturbative transport effects resulting in enhanced O_2-penetration depth (>1 cm), considerably elevated O_2 porewater concentrations, and the absence of a purely diffusive O_2 consumption curve within the sediment. Also somewhat surprising was the fact that negligible seiching occurred during our campaign. In parallel to O_2 microprofile measurements, in-situ redox microprofiles and voltammetric-electrode profiles of sediment cores were obtained to characterize corresponding variations in porewater redox and reduced-metal concentrations, respectively. This novel pairing of measurements shows beautifully the correlation between O_2 availability, shifts in redox potential, and subsequent reduction of available electron acceptors (e.g, manganese oxides). The considerable changes in sediment porewater O_2 concentration observed during the course of our study were not found to affect the redox-gradient position and porewater distribution of reduced metals. This work highlights the influence that current velocity and transient 'dancing' infaunal communities may have on sediment porewater O_2 levels and geochemistry.

08-O   Freshwater carbon: drivers of carbon storage in 100 inland wetlands of Southeast Australia.

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Carbon sequestered in wetland soil presents a valuable opportunity for carbon emissions offsetting through conservation and targeted restoration. While carbon storage has been well studied in coastal wetlands and peatlands, the impact of diverse biota and inundation make carbon storage more variable and complex in inland wetlands. This study aimed to increase the baseline knowledge of the storage and rates of carbon sequestration in inland waters of Victoria and to quantify the impact of ecological and environmental drivers. We collected soil cores and vegetation cover data at 100 inland wetlands across the state and built a model of drivers of soil carbon. This large-scale field program delivered one of the largest bodies of soil carbon data in freshwater wetlands and will increase the potential for carbon storage to fund freshwater restoration through carbon farming initiatives.

08-O   Biogeochemical processes of nitrate in Pétrola Basin: a saline lake-aquifer system.   *Nicolas*

Valiente [1] *- Alfonso Menchen* [1] *- Franz Jirsa* [2] *- Thomas Hein* [3] *- Wolfgang Wanek* [4] *- Juan Jose Gomez-Alday* [1]

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Intense agricultural activities are among the main responsible for degradation of saline wetlands in semi-arid and arid climates due to elevated nutrient inputs. In 1998, the endorheic Pétrola Basin (High Segura River Basin, Central Spain) was declared vulnerable to nitrate (NO_3^-) pollution by the Regional Government of Castilla-La Mancha. This hypersaline lake was classified as a heavily modified waterbody due to the contribution of important inputs of pollutants from agricultural sources and urban waste waters, the latest are discharged directly into the lake without appropriate treatment, to the deterioration of the surface water body. An estimation of the NO_3^- mass reaching the lake from the surrounding streams and wastewater spill gives a figure of about 1.85 tn/year.
Earlier studies showed the two main flow components in the aquifer system: a regional groundwater flow from recharge areas into the lake and a density-driven flow from the lake to the underlying aquifer. The NO_3^- inputs are derived from nitrification of synthetic ammonium fertilizers, and afterwards, NO_3^- is expected to be attenuated around the lake by denitrification (up to 60%) in the saltwater-freshwater interface. Nevertheless, the spatial and temporal pattern of NO_3^- reduction in lake sediments is not known.
In this work, the main pathways for the NO_3^- attenuation linked to the sediment-water interface were clarified using isotope pairing techniques. For this purpose, mesocosms experiments were carried out: organic-rich lake sediment (up to 23% organic carbon content) was incubated for 96 hours with the addition of ^{15}N nitrate tracer as KNO_3. Two factors were modified during the experiments: light and oxic conditions. Analyzing inorganic N-species (n=20) over time (72

hours) showed that NO_3^- attenuation was coupled with an increment in the ammonium (NH_4^+) concentration, from 0.8 mg/L up to 5.3 mg/L, and a decrease in redox values, from 135.1 mV up to -422 mV, in the water column.
In order to know the main microbial pathways in NO_3^- reduction, three different pathways were evaluated: denitrification, dissimilatory nitrate reduction to ammonium (DNRA) and anaerobic ammonium oxidation (Anammox). The complete reduction of 250 µmol of NO_3^- occurred during the first 30 hours of incubation under all the treatments, coupled to a temporal increase in the nitrite (NO_2^-) concentration. The outcomes will support the understanding how hypersaline lakes respond to elevated nutrient loads.

08-O   Quantifying and up-scaling nitrate reduction in the hyporheic zone using [222]Rn disequilibrium.

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The hyporheic zone is an active interface between groundwater, riparian and surface water systems. Exchange and reaction of water, nutrients, and organic matter occur due to variations in surface and groundwater flow regimes, bed topography and active biogeochemistry fueled by bioavailable carbon. There has been an increasing focus on how the residence time of surface water in the hyporheic zone influences biogeochemical reactions. However, there are very few tracers that can be used to measure residence times in-situ, especially in complex groundwater-surface water settings. In this work we have used the natural radioisotope Radon ([222]Rn) as an in-situ tracer for calculating river water residence time in a riffle-pool sequence of the Rote Main River, and combined this information with biogeochemical parameters (DOC and C quality, O_2, NO_3, CO_2). We can clearly observe a dependence of reaction progress on the water residence times. We have used this data to estimate monod and first-order kinetic rates for nitrate and oxygen reduction. Nitrate reduction rates are at the higher end of published values, which is likely due to the continual supply of bioavailable carbon from the river system. We then use this kinetic data to upscale nitrate loss to a 32 km river reach. This work helps to better understand the function and efficiency of the hyporheic zone as a natural filter for redox sensitive species such as nitrate at the groundwater – steam interface

08-P   Source organisms in foam substances of the Chikugo River system in the Hita City area of Japan estimated by biomarkers.

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Foam substances are often distributed in coastal marine and freshwater environments in the world, and are believed to be formed by natural products such as carbohydrates derived from algae and/or vascular plants, rather than synthetic detergents. Foam substances in river and lake environments destroy scenic view in the resort area. Here we studied biomarkers in foam substances of the Chikugo River system in the Hita City area of Kyushu, Japan in order to clarify their source organisms. Foam substances were taken from the Chikugo River system of the Hita City area on 3-5 February 2015. Biomarkers in the foam substances were extracted with ethyl acetate after acidification, and the extracts were dried and saponified with 0.5 M KOH/methanol. The ethyl acetate extracts were concentrated and chromatographed on a silica gel column. Hydrocarbons and polar fractions (fatty acids and sterols) were eluted with hexane and ethyl acetate, respectively. Acyclic and cyclic hydrocarbons, fatty acid methyl esters and sterol trimethylsilyl derivatives were analyzed by a gas chromatography-mass spectrometry.
Stereoscopic microscope observation showed the occurrence of small aquatic insects in the foam substances. Normal-alkanes with the predominance of odd-carbon numbers were detected with bimodal distributions maximizing at C_{17} and C_{27} carbon atoms in the hydrocarbon fraction, along with long-chain branched alkanes (C_{20}-C_{30}) and unresolved complex mixture of hydrocarbons (UCMH). These hydrocarbon gas chromatograms contain epimerized triterpanes (C_{26}-C_{35}) and steranes (C_{27}-C_{29}). Normal-alkanoic acids with the predominance of even-carbon numbers were found with bimodal distributions maximizing at C_{16} and C_{24} carbon atoms, together with branched (*iso* and *anteiso*) alkanoic acids and alkenoic acids. C_{27}-C_{29} stenols and stanols were detected with the predominance of cholesterol in all the foam substances.

Short-chain n-alkanes (C_{15}-C_{19}), n-alkanoic acids (C_{12}-C_{19}) and cholesterol are biomarker of algae and plankton, while long-chain n-alkanes (C_{20}-C_{35}), n-alkanoic acids (C_{20}-C_{34}) and 24-ethylcholesterol are mainly originated from vascular plants. Long-chain branched alkanes may be derived from aquatic insects. Branched alkanoic acids are synthesized by eubacteria. Thermally epimerized triterpanes and steranes as well as UCMH are widely distributed in petroleum products such as diesel fuels, lubricants and asphalts. 24-methylcholesterol is a maker of diatoms and is not abun06-8540dant in all foam substances. These biomarkers revealed, therefore, that organic components in foam substances were mainly derived from microalgae except for diatom with small amounts of insects, vascular plants and eubacteria. The occurrence of UCMH as well as epimerized triterpanes and steranes strongly suggest the contribution of petroleum products from automobiles and road runoff including asphalts. These organic components are important in the formation of foam substances in the river systems.

08-P　Study of elemental concentration in different type of diet juvenile (yoy) fish species in River Szamos.

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The River Szamos is one of the most polluted rivers in Northeastern-Hungary, in Europe. Nowadays the water quality is better, but there is water pollution due to industrial and mining activities. Among aquatic animals fish play an important role in the aquatic food webs and they live in polluted waters. Thus, fish can accumulate metals in high concentrations in their tissues. Metal accumulation in fishes depends on the chemical properties of the elements and different factors such as ecological needs, physiological state, size and age of individuals, their life cycle and life history, feeding habits. The aim of our investigation was to study the elemental concentration in different parts of fish body (in muscle, gill and liver tissues) and to study the differences in level of accumulation in different type of diet juvenile (YOY) fish species in River Szamos. Sampling of fishes was performed in November 2013 in the Hungarian section of River Szamos at Csenger. Three fish species were studied which were characterized with different type of diet: the herbivorous nase (*Chondrostoma nasus*), the invertivorous-benthivorous barbel (*Barbus barbus*) and the omnivorous chub (*Squalius cephalus*). The following elements were analysed with MP-AES: Ca, Na, K, Mg, Fe, Cu, Mn, Pb, Sr and Zn. Our results show that there are no significant differences among fish species based on the elemental concentration of different organs, but at the same time, the bottom-feeding fish species accumulated metals (e.g. Fe and Pb) in higher levels than the species feeding in open water areas. The elemental concentration of macro elements (Ca, Na, K, Mg) was found according to their functions in the organism. The highest concentration of Fe, Cu, Mn, Zn, Pb were found in liver tissues. The concentration of Sr, Mn, Zn were presented at higher concentrations in gills, than other tissues. This result indicates a recent pollution of the river. Our investigation shows that metals deriving from industrial and mining activities can be found in tissues of juvenile fish species in River Szamos. The metal pollution of freshwater fishes can be a potential human health risk.

08-P　O_2 and H_2S microrespiration processes in the sediment-water interface from Petrola hypersaline lake (se Albacete).

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In the sediment-water interface from Petrola hypersaline lake can occur the attenuation of organic (i.e. pesticides) and inorganic pollutants (nitrate) associated redox processes. Oxygen and H_2S microprofiles were measured with calibrated microelectrodes in the water-sediment interface from four cores collected in different locations. Oxygen measurements were performed each 25 μm until a maximum depth of 2 mm was reached. Hydrogen sulfide and pH profiles were performed each 100 μm to a maximum depth of 1 cm. O_2 and H_2S production and consumption rates were calculated from measured concentration profiles by using a simple one-dimensional diffusion reaction model. Oxygen production rate (max. 1.46 $nm/cm^{-3} \cdot s^{-1}$) from the interface to 0.4 mm depth, due to the presence of a photosynthetic biofilm; a consumption zone (max. 0.032 $nm/cm^{-3} \cdot s^{-1}$) is observed from 0.4 mm to 1.2 mm. It was found a net H_2S consumption rate (max. 0.032 $nm/cm^{-3} \cdot s^{-1}$) from the interface to 0.9 mm; from 0.9 mm to 4.8 mm a production zone was detected. In this zone sulfide rate reached a maximun value of 0.025 ($nm/cm^{-3} \cdot s^{-1}$). Afterwards, H_2S concentration decreases

rapidly to a rate of 0.051 nm/cm^{-3}·s^{-1} at 6.6 nm/cm^{-3}·s^{-1} mm. Microzonations of O_2 and SO_4^{2-} respiration in recent organic rich sediments suggest distinct reactive zones and can play an important role in mitigating the organic and inorganic contaminants.

08-P   Nutrient contribution of pelican and cormorant droppings in the shallow Lake Lesser Prespa (Greece) and its effects on water quality variables.   *Yvon Verstijnen*

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Lake Lesser Prespa is part of one of the most important wetlands of Greece and Southern Europe. The Lesser Prespa area is especially important as breeding ground for (rare) birds. Several of those are breeding there in large numbers: Dalmatian Pelican (*Pelecanus crispus*), Great White Pelican (*Pelecanus onocrotalus*), Pygmy Cormorant (*Phalacrocorax pygmaeus*) and Great Cormorants (*Phalacrocorax carbo*). Breeding occurs mainly in reed beds near Lesser Prespa and Vromolimni pond. The lake, however, is experiencing cyanobacterial blooms regularly that could be a threat to the ecosystem functions. Therefore, there is a great need to prevent habitat deterioration and to stimulate conservation of the aquatic habitats in the Prespa area. The first step in mitigation is a diagnosis of the main pollution sources. As likely contributors to nitrogen (N) and phosphorus (P) loadings, triggering eutrophication, agricultural run-off and domestic effluents were identified. Yet, pelicans and cormorants in Lesser Prespa and Vromolimni are potential sources too as they feed mainly outside these waters, bringing external nutrients into the system when defecating in the dense-populated colonies.
It is hypothesised that 1 breeding birds considerably contribute N and P to the lake, 2 water quality variables are affected by spatial heterogeneity of nutrient input and 3 bird droppings have a significant effect on algal growth.
To test these hypotheses, 1 pelican droppings were gathered for nutrient analysis, 2 water quality variables were measured and water and sediment, collected along two transects starting from sites near colonies towards sites further away from colonies, was analysed on nutrients and 3 an experiment was conducted to study the impact of droppings on algal growth. Results show that the N input can be estimated around 1150-1750 kg, during the whole breeding season into Lesser Prespa (±1.9·10^8 m^3). Not much difference is found between dissolved nutrient concentrations of the overlaying water. However, in the sediment pore water and sediments near the colonies, soluble nutrients are present in considerably higher concentrations than at other sites. Furthermore, addition of artificial N and P, and separate addition of droppings to lake water in an experiment led to significantly higher algal growths compared to no addition of artificial nutrients or dropping material. Moreover, cyanobacteria were particularly promoted when lake water was incubated with droppings.
The results indicate that the high abundance colonies of pelicans and cormorants should be taken into account when assessing eutrophication in Lesser Prespa and Vromolimni and should be included in the system analysis deciphering the main sources of nutrient inputs.

08-P   Vertical distributions of trace elements involved in phytoplankton and photosynthetic bacteria in Lake Fukami-ike. *Akihiko Yagi [1] - Megumi Nobori [1] - Hiromi Suda [1] - Eiji Iwatsuki [1] - Maki Oyagi [2] - Akiko Yokoyama [3]*

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Lake Fukami-ike in Nagano Prefecture Anan-cho, a natural meromictic lake, is located in north latitude 35 ° 32'55 "77, east longitude 137 ° 81'93" 56, and measures minor 150 m, diameter 300 m, surface area 2.1 ha, and volume 1.4 × 10^5 m³; it has six inflow rivers, and one outflow river, with a maximum depth of 7.7 m. Lake Fukam-ike is a eutrophic lake and the water temperature stratification is formed annually April to October. It is in the stagnation period about 3.5m deeper. Because of the high sulfate ion in lake water, hydrogen sulfide is found in the deep layer by sulfate reduction. Green sulfur bacteria grow in large quantities in the reduced layer. Water sampling was done every 0.25 m depth using a polyvinyl silicon tube and a hand pump around the thermocline, and other water sampling every 0.5-1 m. Phytoplankton (Chl.a) and the green sulfur bacteria (B-Chl.c) were measured by a spectrometry method. Trace elements were determined by an ICPA method (SHIMAZU ICPA-9000). The correspondence between the vertical distributions of trace elements and that of purple non-sulfur bacteria were studied. Amounts of phytoplankton (Chl.a) and green sulfur bacteria (B-Chl.c) in the water column were calculated for different stratification and circulation periods. As for Chl.a

amounts of 1978 to 2015, the average values observed in the stratification period where $191 \pm 0.153 gm^{-2}$ and the mean value was $0.337 \pm 0.196\ gm^{-2}$ in the circulation period. The Chl.an amount in the circulation period compared to the stratified season was larger. The average value of the stratification period (1979 to 2015) was $0.754 \pm 0.546\ gm^{-2}$, with an average value of $0.091 \pm 0.117\ gm^{-2}$ in the circulation period; as for the results of B-Chl.c a large amount in the stratified season was obtained. Photosynthetic purple non-sulfur bacteria (*Rhodopseudomonas palustris*) in the redox boundary layer top was often confirmed as observable red color even with the naked eye. The vertical distribution characteristics of trace elements were measured in the appearing layers which measured purple non-sulfur bacteria at 5 m depth (May 24, 2014), at 5.25 m (June 14) and at 4.75 m (July 19). The maximum values of the elements of PCa (particulate Ca), PP, PMg and PS appeared at 5 m on May 24 were $0.25\ mgL^{-1}$, $0.25\ mgL^{-1}$, $0.089\ mgL^{-1}$ and $0.0076\ mgL^{-1}$, respectively. Similarly, the maximum values of Pca, PP, PMg and PS appeared at 5.25m on June 14, and were $0.816\ mgL^{-1}$, $0.158\ mgL^{-1}$, $0.086\ mgL^{-1}$, and $0.0028\ mgL^{-1}$, respectively. It should be noted that PCa also took the maximum value in the same way as PMn redox boundary layer. Good correspondence in the layers where the presence of purple non-sulfur bacteria and the appeared maximum values of PCa, PMg, PP and PS were obtained.

08-P   Possible role of extracellular polysaccharides from phytoplankton as an inducer for formation of filamentous manganese oxide particles in Lake Biwa.   *Naoyuki Miyata [1] - Furuta Seiko [2] - Hisato Ikegaya [3] - Hideki Hashimoto [4] - Megumu Fujibayashi [1] - Kunihiro Okano [1] - Jun Takada [5] - Satoshi Ichise [2]*

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The *Metallogenium*-like, filamentous manganese (Mn)-rich particles are a typical morphotype of Mn oxide phases in freshwater lakes and are abundant in stratified water columns and sediments. Field studies have demonstrated that the particles play an important role in the transfer of Fe, C, S, P, and N and trace metals such as Co, between anoxic and oxic zones. The Mn(II)-oxidizing bacteria such as *Bosea* sp. strain BIWAKO-01 are considered as causative agents in the environment, but little is known about how the bacteria produce Mn-rich particles. Our previous study demonstrated that the particle formation by laboratory cultures of BIWAKO-01 occurred only in the presence of gelatinous polysaccharides such as agar and starch, suggesting that such materials may be an inducer for the bacterial particle formation. Our working hypothesis is that encapsulated phytoplankton grown in the upper layer of lakes goes down and serves as resource of polysaccharides in the stratified water columns. In the northern basin of Lake Biwa, Shiga, Japan, we have observed that numerous Mn particles in bottom layer (ca. 90 m) exist in association with gelatinous materials including debris of phytoplankton cells, which are detected using several lectins reactive with specific carbohydrate chains.

In this study, we conducted culture experiments with strain BIWAKO-01. Nanostructural analysis by electron microscopy revealed that the Mn oxide phases produced in the cultures with a low concentration of agar and <0.1 mM dissolved Mn(II) showed birnessite-like sheet structures resembling Mn oxide phases occurring in Lake Biwa. In the medium with encapsulated cells of green algae including *Staurastrum arctiscon* and *S. dorsidentiferum*, the cultures were found to produce the filamentous Mn particles. The algal cells washed repeatedly to remove extracellular gelatinous capsules were not effective, showing the significance of extracellular polysaccharides. Addition of several species of diatoms and cyanobacteria also resulted in the Mn particle formation.

In the northern basin of Lake Biwa, the occurrence of filamentous Mn particles in the bottom layer has been recorded since 1992. We found that there is a positive correlation between annual cumulative values of phytoplankton biomass in surface layer and densities of filamentous particles. The results of this study support our hypothesis that extracellular polysaccharides from phytoplankton are involved in the bacterial formation of filamentous Mn particles in bottom layer of Lake Biwa.

08-P   Structural and functional diversity of some aquatic ecosystems in the lower sector of Jiu (South-Western Romania). *Cioboiu Olivia [1] - Cismasiu Carmen Madalina [2]*

The Oltenia Museum Craiova – Nature Sciences, Museum, Craiova, Romania [1] - Institute of Biology Bucharest of The Romanian Academy, Research Institute, Bucharest, Romania [2]

The structural and temporal heterogeneity of the habitat represents a special property since the transfer of soluble substances by diffusion has a dominant role in determining rates of metabolism in aquatic ecosystems. In this context, we compared rates of the metabolism in natural ecosystems where oxygen and anoxic zones engage active bacteria in the sulfur cycle. On the other hand, the environmental heterogeneity enables interactions between organisms that are unable to increase together in the same homogenous habitat. This phenomenon was observed in the sulphur cycle when aerobic metabolism and forced anaerobic bacteria bound is coupled to the interface between an oxygen area and another anoxygenic area, through compounds that diffuse from one area to another. This paper presents a number of experimental data about the functional diversity of aquatic ecosystem that demonstrates the fundamental role of temperature and humidity in the kinetics of chemical reactions to produce biomass or on various metabolic processes in the microbial evolution. A different major factor for increasing the structural diversity of aquatic ecosystems is the pH value strongly correlated with the concentration of metallic ions in the habitat. Because the freshwater snails can accumulate higher levels of Cu^{2+} and Cd^{2+} concentrations than the levels of environment, they are generally recognized as "macro concentrator" HMS for these species. Making a ranking of the 18 species identified in the chain of lakes depending on the biomass, it was found out that the populations of *Viviparus acerosus*, present the highest share, 147 g/m^2 and 649 g/m^2, this species being a bio indicator for the accumulation of heavy metals in the studied aquatic ecosystems.

08-P   The role of acidity in the measurement of phosphorus.   *Christian Preiler, Robert Ptacnik*

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Phosphorus is of great ecological interest as it commonly limits productivity in aquatic ecosystems. Detection of phosphorus as molybdenum blue is a conventional method in water analytics. Due to its sensitivity it is widely used in manual and automated methods. Both, reaction time and final absorbance were found to be fundamentally influenced by the ratio of acid to molybdate. A surplus of acid leads to slow and incomplete colour formation, while too little acid causes self-reduction of molybdate which results in biased absorbance signals. As the method can only detect PO_4, other phosphorus compounds must be converted into PO_4 by digestion prior to measurement. The digestion procedures typically employ a combination of high acidity, an oxidative environment and heat to break up polyphosphates and organically bound phosphorus. Hence, digested samples often introduce a surplus of acid to the colour forming reaction. This is consequently altering the ratio of $[H^+]:[Mo]$ being the crucial parameter determining reaction rate and magnitude of colour development. Methodical adaptations can compensate for acid introduced with the digested sample and therefore prevent interference with subsequent colour formation. We discuss approaches like (i) adjustment of acidity in reagent solutions, (ii) neutralization after digestion, and (iii) dilution of digested samples. We here summarize the most important caveats and pitfalls in the analysis of dissolved, particulate and total phosphorus. We present experimental data to illustrate the role of the $[H^+]:[Mo]$ ratio on the duration and precision of the molybdenum blue method. Furthermore, we compare the effectiveness of two digestion methods involving different levels of persulfate and temperature.

08-P   Spatial and temporal patterns of limnologic variables in a large subtropical shallow lake.   *Lucia Ribeiro Rodrigues [1] - David Motta Marques [1] - Nelson Ferreira Fontoura [2]*

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Spatial heterogeneity has been recognized as an important feature in a number of lake systems for a wide range of environmental variables. Water transparency, turbidity, total suspended solids (STT), nutrients and chlorophyll *a* concentrations are all key environmental variables related to lake trophic dynamics. Mangueira is a large shallow lake (3 m deep in average, 90 km long, 3-10 km wide, $\sim$ 820 km^2) located along the Atlantic coast-line in southern Brazil. Limnological data were collected at 19 sampling points along a 90 km long latitudinal gradient in the southwestern-northeastern main axis of the lake. The samplings were performed seasonally, from the summer of 2010 to the spring of 2010 (in March, May, August and November). Turbidity (p=0.003), STT (p=0.003), total Phosphorous (TP, p=0.000),

Orthophosphate (p=0.000) and chlorophyll *a* (p=0.000) presented all a negative relationship with latitude (linear regression, b<0), with measured values decreasing from the northeastern to southwestern extremes of the lake. In the other hand, transparency increased in reverse, to southwestern (p=0.000), whereas no latitudinal gradient (no regression) were observed for Total Nitrogen (TN; p=0.317) and Total Dissolved Nitrogen (TDN, p=0.609). Once extracted the latitudinal effect by working with residuals from predicted latitudinal regressions, or by working with the original data set for TN and TDN, ANOVA showed a clear seasonal pattern for all variables. Especially, spring presented higher turbidity values when compared with all other seasons (Tukey, p=0.000) whereas all other season kept similar (p>0.161). On the other hand, TP (p=0.000) and chlorophyll *a* (p=0.000) were larger in summer than in all other seasons, which remained in the same lower range along the year (p>0.146). On summary, the southwestern Mangueira Lake was characterized by increased water transparency, less chlorophyll *a* concentration, turbidity and total suspended solids. In the northern sampling sites, there were increased chlorophyll *a* concentration, turbidity, total suspended solids and lower water transparency. As an average, for the entire longitudinal gradient, turbidity was higher in the spring, whereas TP, TN, TDN and chlorophyll *a* concentrations increased significantly on the summer (also for autumn for TN and TDN). The latitudinal gradient is mainly driven by prevailing winds from northeastern and the large wetland areas of the Taim Hydrological System. On the other hand, seasonal cycles could be driven no only by climatic fluctuation, but also from large rice farming management, where it's usual to flood and drain the rice fields prior to rice plantation in spring (pre-germinated management), carrying sediments to the lagoon and increasing turbidity, whereas the drainage of flooded rice fields to prepare the soil for cropping in autumn could carry nutrients artificially introduced during soil preparation and still do not absorbed by the culture.

08-P　Determination of nanomolar levels of phosphate in water of P-limited lake in japan (Lake Biwa) by ion chromatography.　*Masahiro Maruo* [1] *- Haruki Miyashita* [1] *- Mana Ishimaru* [1] *- Hajime Obata* [2]

School of Environmentall Science, The University of Shiga Prefecture, Hikone, Shiga, Japan [1] *- Atmosphere And Ocean Research Institute, The University of Tokyo, Kashiwa, Chiba, Japan* [2]

For the determination of soluble reactive phosphorous (SRP) in water, spectrophotometry of reduced form of phosphomolybdate is widely used. However, some problems of this method have been pointed out, e.g., interference of arsenate, silicate forming molybdate complexes. Moreover, both polyphosphates and organic phosphorous compounds in natural water are hydrolyzed during the analytical process and release orthophosphate, which causes overestimation of orthophosphate in water. Although detection limit of this method can be improved at some tens of nmol/L to 1 nmol/L levels by using liquid waveguide capillary cell [1], the problems on interference of above-described compounds and CDOMs (especially in humic waters) remain [2].
We developed ion chromatographic determination method of orthophosphate that has a high advantage to avoid interferences of other components. Detection limit was improved by decreasing background conductivity and injecting large volume of sample waters [3]. This combination method was applied to measure orthophosphate in waters of phosphorous limiting lake (Lake Biwa, Japan: mesotrophic).
We obtained a vertical profile of orthophosphate (1 – 360 nmol/L) in Lake Biwa. There is a contamination problem on determination of trace-level (below 0.3 nmol/L) phosphate, but this method has a potential to determine 0.1 nmol/L level of orthophosphate, that was close to the minimum values in lake water obtained by steady-state radiobioassy [4]. SRP concentrations of epilimnetic waters have not been obtained because of less sensitivity of usual spectrophotometry. By comparing the concentrations of SRP in hypolimnetic waters with those of orthophosphate by this ion chromatographic method, we found that orthophosphate content increased with the depth and almost matched with SRP values in the depth close to the lake bottom.

08-P　Effects of seasonal variation and tidal regimes on the physical and chemical parameters of the Warri River, Nigeria.　*Anthony Ekata Ogbeibu, Iyobosa Stella Edogun*

University of Benin, University of Benin, Benin City, Nigeria

A study was conducted on the coastal Warri River in southern Nigeria from July 2014 to February 2015 to determine the effects of seasonal variation and tidal regimes on the physical and chemical properties of the water body. A 2 x 2 x 5 factorial experimental design was used to test for significant difference in water quality due to effects of tidal regimes,

seasons, and factor interaction. Samples for water quality parameters were collected from five longitudinal stations from headwater to mouth to cover high and low tidal regimes during the wet and dry seasons. The physical and chemical parameters comprising nutrients, cations, anions and heavy metals were analyzed using standard methods.

Physical and chemical parameters showed significant ($P<0.05$) seasonal variations, with most parameters having higher concentrations in the dry season. Concentrations of these parameters also varied with tidal regimes with values higher in the low than in the high tide. The effect of factor interaction on the water quality was not significant, except for temperature, transparency and water level ($P<0.001$). Highly significant spatial variation in water quality parameters was also noticed along salinity gradient. The Principal Component Analysis (PCA) revealed that Chromium, Zinc, Copper, Cadmium, Iron, Manganese, Vanadium, Total Hydrocarbon Content, Ammonium nitrogen, Phosphorus, and Nitrate were the principal parameters controlling the water quality of the study stretch of the Warri River. In general, seasonal variation and tidal regimes influenced the water quality of the Warri River.

The time of sampling is critical in the assessment and interpretation of water quality results in coastal rivers. Results are therefore more authentic and holistic when sampling in coastal tidal rivers takes into account tidal and seasonal variations.

08-P Relationship between phycocyanin and cyanobacterial biomass at the different trophic state in shallow lakes.   *Hajnalka Horváth [1] - Mátyás Présing [1] - Lajos Vörös [1] - Piroska Rádóczy [2] - Eszter Zsigmond [3] - Attila Kovács W. [1]*

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Phycocyanin (PC) is one of the water-soluble accessory pigments, and its concentration in aquatic systems can be used to estimate the presence and relative abundance of cyanobacteria. However, PC concentration in the cells depend on the environmental variability, especially light quality and nitrogen sources.

We investigated the influence of nutrient (notably dissolved nitrogen) levels on PC concentration and determined the relationship between PC concentration and cyanobacterial biomass at different trophic states.

The study areas were in the southern catchment area of Lake Balaton (Hungary). The selected water bodies (39) are characterized by different trophic class (from oligo-mesotrophic to hypertrophic) and diverse algal composition.

Total dissolved nitrogen (TDN) and total nitrogen (TN) concentration of the examined water bodies ranged between 500–2350 µg l^{-1} and 1000–12000 µg l^{-1}, respectively. PC concentration varied from 5 to 4200 µg l^{-1}. A relatively close non-linear correlation was found between TN and PC concentration ($R^2 = 0.7416$), however, significant correlation ($R^2 = 0.2977$) between TDN and PC concentration was not observed.

Total algal biomass (0.485 mg l^{-1} – 120 mg l^{-1}) and cyanobacterial contribution (0–95%) varied on a large scale. Strong linear correlation ($R^2 = 0.9069$) was observed between PC concentration and cyanobacterial biomass.

Our results verified that the PC concentration is a valuable indicator for the routine monitoring of cyanobacteria in water bodies of different tropic state.

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08-P Ecosystem metabolism and chlorophyll dynamics in a tropical maar lake, Mexico.   *L. Alberto Vizuet-Martinez [1] , Laura Soriano Peralta [2], J. Salvador Hernández-Avilés [1]*

Biology Dept. Limnoecology lab. Fes Zaragoza, Universidad Nacional Autónoma de México, Ciudad de México, Mexico [1] - Proyecto de Investigación en Limnología Tropical Fes Iztacala, Universidad Nacional Autónoma de México, Tlalnepantla, Mexico [2]

This research evaluates the metabolism and chlorophyll a (Chla) dynamics of volcanic Lake Atexcac in two consecutive years, in order to determine the seasonal and inter-annual variation of gross primary production and respiration rates associated to deep chlorophyll maximum formation under different rainfall regimes. The gross primary production (GPP) and respiration (R) rates were quantified from February 2013 to October 2014, in accordance with changes of the dissolved oxygen content through the light-dark bottle incubation method. While the Chla concentration was

determined by *in vitro* fluorescence. Also, inorganic nutrient concentration was measured by means of colorimetric methods.

According to the average GPP rate and average chlorophyll concentration the lake was classified as mesotrophic; however, the system had a maximum GPP during the bloom of the filamentous cyanobacteria *Nodularia spumigena* Mertens and then the chlorophyll maximum concentration was observed in the surface in both years indicating a tendency towards eutrophication. The R value had high annual and inter-annual variability with a maximum during the 2013 stratification (5.12 g C m-2 day-1), which was associated with the increased oxygen demand caused by the input of allochthonous organic matter from the catchment basin because of rainfall.

The net ecosystem productivity (NEP) was negative during 2013 and positive during 2014, thus indicating an inter-annual change in system behavior from heterotrophic to autotrophic. The deep chlorophyll maximum (DCM) was associated with the density gradient in the thermocline during stratification coupled with the process of photoacclimation and nutrient accumulation.

Furthermore, a strong variation in inorganic nutrient concentration was observed. Thus, a higher concentration of nitrogen and phosphorus was recorded in 2013 and both were twice times high than concentrations measured in 2014, as a result of differences in organic matter inputs.

Based on this research, the dynamics of the photoautotrophic community of the system should be portrayed in the form of pulses associated with nutrient availability and as an adaptive response by specific groups that tend to fully develop when one of the nutrient is limiting. In addition, the study shows the potential of Lake Atexcac as a site for studying the short-term effects of climate change because of its immediate response to changes in rainfall-evaporation regimes.

09. ECOLOGICAL STOICHIOMETRY IN AQUATIC ECOSYSTEMS: RECENT ADVANCES AND FUTURE PERSPECTIVES

09-O   The effect of varying temperature on *Daphnias'* nutrient requirements.   *Cecilia Laspoumaderes* [1] - *Esteban Balseiro* [1] - *Beatriz Modenutti* [1] - *James Elser* [2]

INIBIOMA, CONICET, Universidad Nacional del Comahue, San Carlos de Bariloche, Argentina [1] - *Arizona State University, Arizona State University, Tempe, United States* [2]

Nutrient availability and temperature play key roles in controlling the pathways and rates at which energy and materials move through ecosystems. The role of nutrient availability is mediated by imbalances between the demand from organisms and the relative availability of required resources in the environment. Temperature, on the other hand, controls biological activity through its fundamental effect on metabolic rate. Although significant effort has been devoted to understanding the role of nutrients and temperature in isolation, virtually nothing is known about how these two factors interact to influence ecological processes. In this work we evaluate if nutrient requirements in terms of C:P change with temperature and particularly analyse if this change is towards higher or lower C:P ratios with increasing temperature. We analysed growth rates of Daphnia magna and Daphnia commutata in a food quality (C:P 50-1000) and temperature gradient (15-28 °C). We also determined the C:P threshold elemental ratio (TERC:P) at 10°C and 20°C on both Daphnia species. The TERC:P is a key concept for understanding nutrient deficiency in animals, is the C:P ratio of the food at which organisms growth limitation switches from one element to another. This is a direct measurement to determine whether organisms need higher or lower C:P with increasing temperature. Also, the calculation of the TERC:P includes the estimation of assimilation efficiency of C and P, through the measurement of C and P ingestion, egestion, excretion, and respiration rates. By analyzing these parameters on both species at different temperatures we can reveal the metabolic pathways that are being affected by temperature for each nutrient, and find out if temperature is driving a differential nutrient recycling. Our results reveal a complex interaction among temperature and nutrient requirements, showing that nutrient requirements of Daphnia change with temperature. Indeed, the interaction is stronger at higher temperatures, while at lower temperatures growth is less affected by varying food quality. The analysis of the TERC:P supports the previous results and showed that C and P assimilation efficiency are strongly affected by temperature, driving the differential nutrient demands in warmer waters. A better and broader understanding of the interactions among temperature and nutrients is clearly needed for developing realistic predictions about ecological responses to drivers of global change that include climate warming and varying nutrient supply to ecosystems.

09-O   Inter- and intraspecific variability in aquatic fungal stoichiometry.   *Isabel Fernandes* [1] - *Cláudia Pascoal* [1] - *Fernanda Cassio* [1]

Centre of Molecular and Environmental Biology (CBMA)/ Institute for Science and Innovation For Bio-sustainability (IB-s), University of Minho, Braga, Portugal [1]

Ecological stoichiometry investigates how the ratios of elements in organisms shape their ecology and nutrient and energy fluxes in ecosystems. Litter decomposition in streams is a key ecosystem process mainly driven by microorganisms (fungi and bacteria) and invertebrate detritivores. Although aquatic fungi play a major role in litter decomposition, little is known about their elemental stoichiometry.
We used fungal strains isolated from streams with different nutrient concentrations. Fungal strains of the same species (intraspecific traits) and different species (interspecific traits) were grown in mineral medium with increasing concentrations of nitrogen as KNO_3, to assess fungal biomass accrual and elemental stoichiometry. At higher nitrogen concentrations, C:N ratios of *Tricladium chaetocladium* strains (C:N=9-52) were on average 2-times lower than C:N ratios of *Articulospora tetracladia* strains (C:N=22-86). Supplementation with nitrogen did not stimulate fungal biomass accrual but led to a 4-fold decrease in C:N ratio of all tested strains of *T. chaetocladium*. Supplementation above 50 mg/L KNO_3 did not cause further decreases in C:N ratios. On the contrary, biomass accrual of strains of *A. tetracladia* (AT72 and AT61) was stimulated at KNO_3 concentrations above 50 mg/L (AT72) and 200 mg/L (AT61). Supplementation with KNO_3 lead to a faster decrease of C:N ratio in the strain AT61 than in the strain AT72, whose lower C:N values were only observed for concentrations above 200 mg/L KNO_3.

Fungal communities associated with decomposing leaf litter in streams comprise several species (interspecific diversity) but also several strains from the same species (intraspecific diversity), which may differ in terms of their elemental stoichiometry. Changes in environmental variables, such as nutrient enrichment in streams, may lead to changes in the structure of fungal communities potentially leading to changes in communities' stoichiometry (e.g., if *T. chaetocladium* becomes dominant over *A. tetracladia*; if strains from same species but different traits become dominant). But also, nutrient enrichment *per se*, may lead to changes in fungal stoichiometry, leading to alterations of litter nutrient content with possible consequences to higher trophic levels. More fungal species and strains need to be assessed regarding their elemental stoichiometry and homeostasis capacity to better predict effects of global change on detritus food webs.

09-O   The ecological stoichiometry of a fungal parasite infection.   *Thijs Frenken* [1] *- Joren Wierenga* [1] *- Alena S. Gsell* [1] *- Ellen van Donk* [1] *- Thomas Rohrlack* [2] *- Dedmer B. Van de Waal* [1]

Aquatic Ecology, Netherlands Institute of Ecology, Wageningen, Netherlands [1] *- Norwegian University of Life Sciences, Norwegian University of Life Sciences, Ås, Norway* [2]

Human activities have dramatically altered the fluxes of nutrients from the landscape into receiving waters. Aquatic systems receive generally an increased nutrient input, leading to high primary production and ultimately limitation by nitrogen (N) and/or phosphorus (P). These nutrient limitations are predicted to also affect parasitism as parasites are completely dependent on their hosts' nutritional quality which, in turn, is determined by environmental nutrient conditions. We hypothesize that host nutritional quality affects parasite elemental composition (stoichiometry) and reproductive success (i.e. rate of change in infection prevalence over time). Here, we tested this hypothesis by following the response of a host-parasite system to N and P limitation in a controlled laboratory experiment. We exposed a fungal parasite (chytrid) to its host (cyanobacterium) that exhibited a range of N:P ratios. Our results demonstrate that changes in parasite N:P stoichiometry reflect those of their host. Furthermore, higher N:P ratios caused an increase in the amount of zoospores produced by the parasite resulting in a changed prevalence of infection. Since zooplankton was shown to graze on chytrid zoospores, such changes in parasite production and stoichiometry may have implications for the success of higher trophic levels.

09-O   Changes in the functional response of the consumer Brachionus Calyciflorus in response to resource stoichiometry.   *Kimberley Lemmen* [1] *- Björn C. Rall* [2] *- Sebastian Diehl* [3] *- Steven A.J. Declerck* [1]

Department of Aquatic Ecology, Netherlands Institute of Ecology, Wageningen, Netherlands [1] *- Theory In Biodiversity Science, German Centre For Integrative Biodiversity Research, Leipzig, Germany* [2] *- Department of Ecology And Environmental Sciences, Umeå University, Umeå, Sweden* [3]

Anthropogenic alteration of the availability and relative ratios of essential elements (e.g. carbon, nitrogen, phosphorus) is a major stressor in freshwater systems. In contrast to primary producers, consumers exhibit more constrained C:N:P ratios, and may therefore have mechanisms to mediate the uptake of limiting as well as excess nutrients in the face of nutritional imbalance. Compensatory feeding has been suggested as a mechanism to deal with resource limitation as it allows consumers to increase the number of food particles consumed, and therefore the amount of the limiting resource. However, such a response may also lead to an increased uptake of excess nutrients. Alternatively, consumers may decrease the number of particles consumed in order to increase assimilation efficiency of the limiting nutrient by increasing gut retention time. Previous studies have suggested that only growth rate is impacted by changes in algal stoichiometry. However, we have found evidence for increased ingestion rate in response to phosphorus limitation, providing evidence for compensatory feeding in the consumer *Brachionus calyciflorus*. The observed differences in functional response as a result of nutrient limitation suggest that resource stoichiometry has an important role in consumer-resource interactions. However, an additional experiment showed lower ingestion rates of animals fed with P-replete algae compared to animals fed with algae with similar C:P ratio but with a history of growth under P-limitation. These results indicate that elemental content is not the only determinant and that other morphological or biochemical cues may also be responsible for quality-related changes in feeding behaviour.

10. ORGANIC MATTER DYNAMICS AND MICROBIAL BIODIVERSITY IN FRESHWATERS

10-O   Production of dissolved organic matter by phytoplankton and its uptake by heterotrophic prokaryotes in large tropical lakes.   *Cédric Morana,[1], Hugo Sarmento[2,3], Jean-Pierre Descy[4], Josep M. Gasol[3], Alberto V. Borges[5], Steven Bouillon[1], François Darchambeau[5]*

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[2] *Federal University of São Carlos (UFSCar), Department of Hydrobiology (DHb), São Carlos, Brazil*
[3] *Institut de Ciències del Mar – Consejo Superior de Investigaciones Científicas (CSIC), Barcelona, Catalunya, Spain*
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In pelagic ecosystems, phytoplankton extracellular release can extensively subsidize the heterotrophic prokaryotic carbon demand. Time-course experiments were carried out to quantify primary production, phytoplankton excretion, and the microbial uptake of freshly released dissolved organic carbon (DOCp) in 4 large tropical lakes distributed along a productivity gradient: Kivu, Edward, Albert, and Victoria. The contributions of the major heterotrophic bacterial groups to the uptake of DOCp was also analyzed in Lake Kivu using microautoradiography coupled to catalyzed reporter deposition fluorescent in situ hybridization.

The percentage of extracellular release (PER) varied across the productivity gradient, with higher values at low productivity. Furthermore, PER was significantly related to high light and low phosphate concentrations in the mixed layer, and was comparatively higher in oligotrophic tropical lakes compared to their temperate counterparts. Both observations suggest that environmental factors play a key role in the control of phytoplankton excretion.

Standing stocks of DOCp were small and generally contributed less than 1% to the total dissolved organic carbon, as it was rapidly assimilated by prokaryotes. In other words, there was a tight coupling between the production and the heterotrophic consumption of DOCp. None of the major phylogenetic bacterial groups investigated differed in their ability to take up DOCp, in contrast with earlier results reported for standard labeled single-molecule substrates (leucine, glucose, adenosine triphosphate). It supports the idea that the metabolic ability to use DOCp is widespread among heterotrophic prokaryotes. Overall these results highlight the importance of carbon transfer between phytoplankton and bacterioplankton in large African lakes.

10-O   The characteristics of terrestrial dissolved organic matter affecting freshwater algal growth and photosynthesis.   *Amanda Neilen [1] - Darryl Hawker [2] - Kate O'Brien [3] - Michele Burford [1]*

Australian Rivers Institute, Griffith School of Environment, Griffith University, Nathan, [1] - Griffith School of Environment, Griffith University, Nathan, [2] - School of Chemical Engineering, Faculty of Engineering, Architecture and Information Technology, University of Queensland, St Lucia, [3]

Traditionally viewed as inert, it is now well understood that dissolved organic matter (DOM) can both stimulate and inhibit algal growth. The major source of DOM in freshwater catchments is from terrestrial plants in the form of leachates from leaf litter (t-DOM). Interestingly, whether t-DOM inhibits or stimulates algal growth is in part dependent upon the vegetation source. The plant source determine the concentration of bioavailable t-DOM as dissolved organic carbon and nitrogen species, which can stimulate algal growth, as well as the concentration of phenolic compounds that may inhibit algal growth. In this study, we used bioassays to determine the effect of leached t-DOM from nine terrestrial plant species common along riverbanks on growth and photosynthetic performance of two algal species, a green algae and a cyanobacterium. Exposure to the leachate reduced photosynthetic yield in the freshwater cyanobacterium, *Cylindrospermopsis raciborskii*, in all except one t-DOM source, the rush, *Asparagacea sp.* The t-DOM from this source had a relatively lower carbon:nitrogen ratio, a lower molecular mass, a lower content of humic substances, and was more aliphatic, compared to the other plant leachates. Dose-response assays were used to compare thresholds of response to different plant sources, with *C. raciborskii* being more sensitive to DOM than the green algae, *Monoraphidium sp*. In summary, the study has highlighted variability in the responses of two algal species to t-DOM, as

well as differential responses to different t-DOM sources. This information is critical to predicting how revegetation effects in degraded catchments is likely to impact on algal species composition, and ultimately water quality.

10-O   Effects of different dissolved organic carbon sources on bacterial community in a North-Patagonian Andean wetland.   *Marcela Bastidas Navarro, Verónica Díaz Villanueva, Esteban Balseiro, Beatriz Modenutti*

CONICET-INIBIOMA, Universidad del Comahue, San Carlos de Bariloche, Argentina

Dissolved organic carbon (DOC) in aquatic ecosystems comprises a complex mix of compounds of different origin. In North Patagonian Andes, *Nothofagus pumilio* (lenga) determines the upper limit of the temperate forest and constitutes an important source of organic input for the catchment area. In addition the wetlands of the area, locally called *mallín*, develop benthonic algal communities (*Spirogyra* sp and *Zygnema* sp) that provide autochthonous DOC. The objective here was to analyze the metabolism, and genetic and functional diversity of bacterioplankton in relation to different sources of DOC (algal exudates and lenga leachates) in a mountain wetland (Mallín Los Patos). We conducted laboratory experiments in three different seasons (autumn, spring and summer) in which lake water with a bacterial inoculum was enriched with exudates or leachates. We measured nutrient concentrations, bacteria abundances, and we assessed bacterial community structure using next-generation sequencing of the 16S rRNA gene and microplates Ecoplate^{TM}. In addition, we performed bacterial respiration and DOC-decay experiments, and changes in dissolved organic matter (DOM) using spectrofluorometric analysis (excitation-emission matrix spectra, EEMs analysis). DOM characterization showed in both exudates and leachates one peak of protein-like origin and two corresponding to humic-like compound. P content was higher in leachates, with a lower C:P ratio than exudates (197.4 ± 80.1 and 503.95 ± 105.8, respectively). The enrichments with either DOC sources (exudates and leachates) stimulated the bacterial metabolism (higher respiration and DOC consumption rates), but leachates exhibited the highest increase in the C consumption rate likely due to its lower C:P ratio. Both enrichments seemed to developed diverse bacterial communities, since different physiological groups were stimulated in each treatment.

10-O   Are bacterial predators of bacteria important in peri-alpine lakes?   *Stéphan Jacquet*

INRA, Thonon-les-Bains, France

We investigated for the first time the diversity, distribution and abundances of predatory bacteria in three peri-alpine lakes (Lakes Annecy, Bourget and Geneva) at various depths and different seasons. This study reveals that the gram negative obligate predators of other gram negative bacteria referred to as the *Bdellovibrio* and like organisms (BALOs) constitute an important fraction of the bacterial community and are likely to play important roles in the biogeochemistry and microbial world of these fresh water ecosystems. This presentation will shed light on a microbial community still poorly known in such inland waters.

10-O   Linking hydrological, biochemical and microbial community patterns in urban rivers: insights from the River Tevere (Rome, Italy).   *Stefano Amalfitano* [1] - *Stefano Casadei* [2] - *Andrea Butturini* [3] - *Stefano Fazi* [1]

Water Research Institute (IRSA- CNR), National Research Council of Italy, Rome, Italy [1] *- Department of Civil And Environmental Engineering, University of Perugia, Perugia, Italy* [2] *- Department of Ecology, University of Barcelona, Barcelona, Spain* [3]

River waters at lowland reaches experience a direct disturbance owing to increasing water resource exploitation and urbanization, with important implications for ecosystem functioning and services. Despite decreasing water quality and altered hydrological regime may dramatically affect the natural processes as a whole, little is known on the effects on aquatic microbial communities, whose dynamics play a key role in organic matter decomposition and nutrient cycling along the river continuum.

The objective of this study was to explore the links between hydrology, water chemistry and microbial community structure in a highly impacted Mediterranean river. To this aim, the catchment of the River Tevere (including the main stem, the major tributary Aniene, and the stream Cremera) was sampled at the closing section in differently urbanized areas at two contrasting seasons (winter/summer). The major hydrological, physical and chemical characteristics of river waters were measured directly or retrieved within datasets from monitoring agencies. The microbial community structure was analyzed by NGS Illumina profiles and flow cytometry to identify and quantify the aquatic prokaryotes and picoeukaryotes (i.e., heterotrophs and photoautotrophs).

Our results outlined recurrent patterns and quantitative changes of interacting microbial assemblages across the urbanization gradient at different hydrological settings. *Alphaproteobacteria* largely dominate the microbial community, followed by *Verrucomicrobia* and *Betaproteobacteria*. The total prokaryotic cell abundance increased toward the river mouth, with higher values registered downstream the city of Rome (4×10^6 cells/ml). The per-cell nucleic acid content, intended as a proxy of the cell metabolic activity, increased accordingly, while the ratio between photoautotrops and heterotrophs decreased downstream the confluence with main tributary.

Given the links between hydrological and microbial community patterns, river microbes could provide valuable indications on the ecological effects of urbanization and altered environmental conditions. Moreover, flow cytometry seems an appropriate tool to rapidly provide multi-parametric data for a better understanding of the biogeochemical processes at the microscale level in river systems.

10-O   Fate of antibiotic resistance genes within the microbial communities of three waste water treatment plants. *Andrea Di Cesare, Ester Eckert, Silvia D'Urso, Julia Doppelbauer, Gianluca Corno*

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Although Waste Water Treatment Plant (WWTP) are designed to reduce the biological pollution of urban waters, they lack a specific action against antibiotic resistance bacteria (ARB) or antibiotic resistance genes (ARGs). Nowadays, it is well documented that WWTPs constitute a reservoir of antibiotic resistances and, in some cases, they can be a favorable environment for the selection of ARB. This represent a serious concern for the public health, because the effluents of the WWTPs can be reused for different applications. There is a need for knowledge about the ARGs removal efficiency by different disinfection processes and the potential regrowth of ARB during and after the different wastewater treatments. Moreover, only a few punctual studies determined the role of the antibiotic resistance selection systems in the stabilization of the ARGs within the microbial community of a WWTP. To shed light on these issue, we analyzed three WWTPs with different disinfection treatments (Verbania: chlorination, Cannobio: peracedic acid, and Novara: UV radiation). We performed different sampling strategies: i) integrated samples of three days and of 24h to evaluate the removal of ARGs in each plant and the potential regrowth (each sample was incubated for 96h at 12°C) of ARB and ii) point samples of water at the end of each treatment. The microbial community of each water sample has been counted by flow cytometry to determine the bacterial numbers and their aggregational state. DNA estracts from each sample were analyzed for the abundance of antibiotic resistance genes (ARGs) (*bla*TEM, *bla*CTXM, *tet*A, *qnr*S, *erm*B, *sul*II) the mobile element integron 1 and the heavy metal resistance genes (HMRGs) (*czc*, *ars*B) by qPCR. The prokaryotic cell abundances drastically reduced from the input to the output water, but no significant reduction was observed during the disinfection treatments regardless to the WWTP location. The regrowth experiments showed that the ARGs were significantly reduced in the input water and in the pre-disinfection water (comparing the data pre- and post-incubation) for all three WWTPs, while they were stable in the effluent for the Verbania WWTP, and they decreased in effluents from Cannobio and Novara ones. Altogether, these results demonstrate that WWTPs efficiently remove bacterial cells, however the different disinfection treatments do not impact the bacterial cell numbers and, moreover, in Verbania WWTP, during the disinfection, there is selection towards ARGs. This suggests specific selection pressures within the microbial community of a WWTP, which can co-select for ARGs leading to the not successful functioning of the disinfection treatment. This hypothesis was confirmed by the significant correlation between genes *sul*II, *czc*, *ars*B and *int*1. In conclusion, this study point out the need for knowledge on the mechanisms and the selective pressures that promote the stabilization of ARB within the microbial community of WWTPs.

10-O Effects of taxonomic vs. functional richness on leaf litter decomposition.   *Silvia Monroy* [1] - *Alan Mosele-Tonin* [2] - *Jesús Pozo* [1] - *Ana Basaguren* [1] - *Junior Gonçalves Jr.* [2] - *Richard G. Pearson* [3] - *Bradley Cardinale* [4] - *Luz Boyero* [1]

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We are facing biodiversity loss at unprecedented rates and there is unequivocal evidence that such loss can alter ecosystem functioning. However, our mechanistic understanding of the effects of diversity loss on vital functions such as plant litter decomposition is still in its infancy. Recent studies suggest that functional diversity (i.e., the diversity of functional traits) may be more relevant than species richness to predict changes in decomposition rates, but there has been no formal test of the relative importance of these two measures of diversity. We examine this question in a microcosm experiment with the stream detritivore *Sericostoma pyrenaicum*, and plant litter combinations differing in a key functional trait (nitrogen (N) fixing capacity) and species richness (1, 2 or 4). N-fixer species were *Alnus glutinosa* and *Robinia pseudoacacia*, and non-N-fixers were *Salix atrocinerea* and *Populus nigra*. Although we predicted that decomposition would be mostly affected by the number of functional types present, rather than the number of species, due to functional redundancy, our results indicate that mixing both N-fixer and non-N-fixer plants does not result in accelerated decomposition. In contrast, increasing the number of plant species in mixtures consistently resulted in accelerated decomposition, both with and without detritivores. We further manipulated water N concentration (natural vs. enriched) and predicted that any effect of the N-fixing trait would be more important when there is less N available in the water. We found, however, no interaction between the functional type and N concentration, although the latter modulated the effect of species richness on decomposition when detritivores were absent: the addition of N resulted in faster decomposition at higher species richness levels, while the opposite pattern was found at natural N concentration. As a whole, our results suggest that decomposition is more importantly driven by species richness than by the number of functional types present (in relation to the functional trait explored here) and that the environmental context can act as an important mediator of diversity effects on decomposition.

10-O   Estimation of primary production in Lake Kasumigaura by using in situ measurement by fast repetition rate fluorometry (FRRF).   *Kazuhiro Komatsu* [1] - *Akio Imai* [1] - *Noriko Tomioka* [1] - *Noriko Takamura* [2] - *Megumi Nakagawa* [2] - *Takayuki Satou* [1] - *Koichi Shimotori* [1] - *Ayato Kohzu* [1] - *Ryuichiro Shinohara* [1]

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Primary production (PP) is the basis of aquatic food webs and thus an important ecosystem function for understanding the organic carbon cycle in aquatic environments. PP has usually been measured by the incubation methods such as ^{14}C-, ^{13}C- and $^{18}O_2$-methods. However, they suffer from the disadvantages of taking time (sometimes several hours) and the difficulty of applying in situ. FRRF (Fast Repetition Rate Fluorometry) is one of the techniques for measuring PP by analyzing the chlorophyll fluorescence and quantifying the photosynthetic electron transport through photosystem II of phytoplankton. The FRRF measurement is desirable because it is instantaneous, non-destructive, non-radioactive, and allows for in situ measurement of PP.
To establish the technique of FRRF and assess its validity, we compared the estimates of PP derived from fluorescence by means of FRRF with those measured by ^{13}C-method (one of the popular method for measuring PP). These comparisons exhibited the high correlations between FRRF and ^{13}C-method (r^2=0.93-1.00); however, the slopes of FRRF: ^{13}C in regression were usually found to be below 1.0, which means the underestimation of PP measured by FRRF as compared with ^{13}C method. On the other hand, exceptionally the slope exceeded 1.0 in the spring season (February and March). The differences between the results of FRRF and the ^{13}C-method were likely due to the difference in the predominant algal species. In Lake Kasumigaura, the contribution of blue-green algae to PP seems to be reasonably large especially in summer; however, the wavelength of the excitation light irradiated by the FRRF equipment was around 450nm for the purpose of measuring PP mainly by green algae or diatom. The measurement sensitivity of PP by

blue-green algae was considered to be low. This hypothesis was supported by the result of PP of cultivated diatom and blue-green algae (*Aulacoseira granulate* and *Synechococcus sp.*) in the laboratory.

Finally, we measured the PP rates by using FRRF before/after algal bloom in 2012, and it is revealed that the water bloom does not absolutely have the linkage to the rate of primary production. For example in July, Chl.a concentrations were higher in the two bays of Lake Kasumigaura (62 and 68μg/L) than in the lake basin (50μg/L), which was the opposite results of PP measured by FRRF (0.065 and 0.022 mgC/g-Chl.a/s in the two bays; 0.221 mgC/g-Chl.a/s in the lake basin).

10-O   Genomic insights into litter breakdown in acidic pit lakes.   *Melanie Blanchette, Mark Lund*

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Open-cut mining can create pit lakes when pits are flooded by ground or surface waters following cessation of operations. The Collie Lake District is formed from open cut coal mining operations in the south-west of Western Australia and consists of 10 pit lakes. Localised factors at the lake level ensure that individual pit lakes develop different water qualities and ecological values. All of the deep pit lakes (<85 m) appeared to be thermally stratified over the summer but with one exception mixed in autumn (warm monomictic). The lakes were mainly Al buffered, with pH ranging from 2.5 to circum-neutral. Most lakes could be considered oligotrophic but some contained high N and moderate P concentrations. Dissolved organic C and metal concentrations were generally very low.

Nutrient limitation, particulaly of C has been idenitified as major barrier towards ongoing ecosystem development. A proposed intervention to speed up development using additions of organic matter was tested using leaf packs. Leaf packs (in bags >3 mm mesh) for a common local species (*Typha orientalis*) and a control (plastic strips) were constructed. Approximately a 1.24 m^2 surface area worth of material was added to each litter bag. Three litter bags per treatment were added to five random sites within five pit lakes. One bag from each treatment was harvested by SCUBA (2-4 m deep) per site on days 20, 92 or 245. In addition, on each sampling trip a <15 mm deep sediment sample was collected with a sawn-off syringe (30 mm dia.). Within a few hours of collection, 20 random leaf punches (4 mm dia.) from material in each collected litter bag and the sediment sample were frozen at -80 °C for later microbial community analysis. Next generation sequencing was used to identify microbial communities following DNA extractions.

Ordination of the sediment microbial community (Order level) revealed for the sediment that assemblages varied across sites witin a lake but were not different between lakes. The leaf litter data in ordination separated signigficantly (P<0.001; Global R = 0.844) by lake along one axis in response to a pH and ORP gradient – within lake variability was not significant. Soil and leaf litter microbial communties were significantly different (p<0.01; Global R=1.0).

We conclude that the low interactivity of the sediment with the water column ensures that micro-habitats within the pit lakes are more significant for determining microbial communities that in leaf litter where exposure to the water column is more important in structuring communities than local micro-habitats. We discuss how microbial communities might influence the breakdown of leaf litter and what benefit the litter may bring to the pit lake.

10-O   Changing substrate quality within an organic matter pool drives the role of fungi and bacteria on carbon cycling differently.   *Jenny Fabian [1] - Sanja Zlatanovic [2] - Michael Mutz [2] - Premke Katrin [1]*

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Organic matter quality was recently observed to play a major role for the microbial processing of organic sources in aquatic ecosystems. In general, the quality of a source can be defined by the complexity of its biomolecular structure and its nutrient composition (stoichiometry). In particular, the stoichiometry, ratio of C:N:P, has often been discussed to modify the resource use by microbes. In an experimental approach, we aimed to disentangle the effects of both quality parameters on the turnover of particulate organic carbon (POC) in stream sediments. Treatments included two algae sources of differing stoichiometry and beech leaves characterised by a more complex molecular structure. The microbial mineralisation of both ^{13}C-labelled POC sources was investigated via respiration (^{13}C-CO$_2$ emission) and compound specific analysis (^{13}C-phospholipid fatty acids). Addition of algae to sediments enhanced overall carbon mineralization independent of algae stoichiometry whereas mineralization of beech leaves was only enhanced in presence of nutrient enriched algae. Observed differences in carbon turnover coincided with shifts in microbial community composition. In conclusion, activities as well as community composition were influenced by POC quality.

However, a nutrient effect could only be observed for the mineralisation of more complex carbon sources implying a linkage between both quality parameters.

10-O   Importance of fungal diversity on litter decomposition under temperature fluctuations in streams.   _Ana Lúcia Gonçalves_ [1] - _Ana Virgínia Lírio_ [1] - _Cristina Canhoto_ [1]

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Stream ecosystems were permanently subjected to environmental fluctuations, being the water temperature one of the major variable factors that may be important for determining the variability of biological communities and its performances, fungi included. We tested if species-rich fungal assemblages are functionally more efficient in leaf decomposition under environmental fluctuations than species-poor assemblages. We manipulated temperature fluctuations in laboratory microcosms in which oak leaf discs were inoculated with monocultures of aquatic hyphomycetes or random mixtures of three or eight species and subjected to different temperature regimes, including three constant temperatures and temperature fluctuation regimes. Temperature regime and identity of fungal species inoculated in monoculture microcosms significantly affected decomposition rates: these increased with temperature, but across all temperature regimes species diversity promoted higher decomposition rate, although functional saturation seemed to occur above three species. In assemblages with at least eight species, litter decomposition was not inhibited by temperature fluctuating regime when compared with constant temperature conditions. Ecosystem function under environmental changes seems to benefit from the presence of multiple species.

10-O   Dissolved organic matter composition structures heterotrophic microbial communities in temperate lakes.   _Robert Taube_ [1] - _Hans-Peter Grossart_ [2] - _Katrin Premke_ [3]

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Climate change leads to an increasing inflow of dissolved organic matter (DOM) from terrestrial to aquatic systems. Observations of increasing concentrations of DOM have recently been reported from many regions worldwide. In most aquatic systems, a large proportion of DOM is not produced in the water column (autochthon), but originates either from the surrounding terrestrial watershed or from littoral sources (allochthon). DOC varies strongly in quantity and composition between different lakes and represents a source of carbon and energy for heterotrophic microorganisms. In particular during autumn littoral sediments of temperate lakes are hotspots for microbial carbon turnover.
To identify the key abiotic drivers for littoral benthic microbial community structure in temperate lakes, we investigated 20 lake ecosystems in North-East-Germany during autumn 2014. The lakes represented a gradient in DOC concentration and pH and differed in size, morphology and catchment area resulting in distinct DOM compositions.
We analysed basic water and sediment parameters of the littoral zone and approached pelagic DOM composition with size exclusion chromatography (LC-OCD), fluorescence spectroscopy and absorption spectroscopy. The microbial community composition was investigated via patterns of phospholipid derived fatty acids (PLFA) focusing on indicator PLFAs for bacterial and eukaryotic heterotrophs. To identify a linkage between the different carbon sources and the microbial community we used C^{13} stable isotope analysis of PLFA, DOM, particulate organic matter and the upper sediment layer.
Our results revealed that DOM composition is a main driver for lake characterisation regarding autochthony or allochthony. The patterns of DOM composition correlate with benthic PLFA patterns between the lakes indicating a more heterotrophic or autotrophic character of the respective lakes. Furthermore, preliminary results indicate that DOM concentration, pH and C:N ratio represent key descriptors for benthic microbial community structure. Consequently, the benthic microbial community composition can be regarded as a result of these key parameters. Further studies need to proof whether a through description of these key variables is sufficient to characterise microbial community composition and their activities.

10-O   Bacterial diversity during whiting events in lakes La Preciosa and Atexcac, Mexico.   *Salvador*

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Lakes La Preciosa and Atexcac are amongst a series of *maar*, athalassohaline lakes that occur in the Trans Volcanic Belt in Central Mexico. La Preciosa is a subsaline lake (Total dissolved solidsTDS= 1.08 ± 0.04 g L^{-1} and electrical conductivity of water EC= 2,150 ± 79 μS cm^{-1}) whereas Lake Atexcac is considered hyposaline (TDS=6.04± 0.14 g L^{-1}, EC = 12,170 ± 280 μS cm^{-1}). Both lakes are found between 2,300 and 2510 m.a.s.l., and have a monomictic thermal regime with mixing during cold-dry period (December-March). Water temperature ranged in both lakes between 14-21.5 °C, dissolved oxygen fluctuated between 0-9 mg L^{-1} and average pH was 8.9±0.2 in 2014. La Preciosa and Atexcac displayed a characteristic whiting event during the well-established stratification period (August-September), with decrease in the euphotic zone of 15 m compared to the mixing period, furthermore pH rose around 9.2 in the superficial strata; carbonate alkalinity reached 10.5 and 23 meq L^{-1} respectively in each lake.

High-throughput genetic survey of surface water samples were collected before (February, 2014) and during (August-September, 2014) the whiting events in both lakes with Illumina 16S rDNA itag sequencing of the V4 hypervariable region (Caporaso et al., 2010). A total of ~4,000,000 sequences were obtained that show an increase in *Synechococcus* in both lakes, being the most abundant bacteria in Atexcac during the whiting event, together with *Candidatus Aquiluna, Candidatus Rhodoluna, Candidatus Xiphynematobacter, Opitutus and Verromicrobium*. Genetic composition in La Preciosa also changes during the whiting event with increases in *Candidatus Xiphynematobacter, Acinetobacter, Alivibrio, Alteromonas, Azohydromonas, Luteimonas, Methylophaga, Paracoccus, Photobacterium* and *Rhodobacter*. Before the whiting event, the most abundant bacteria were *Acholeoplasma, Acinetobacter, Alteromonas, Flavobacterium, Limnobacter, Oceanicaulis, Paracoccus, Pseudoalteromonas, Pseudomonas, Rhodobacter and Vibrio* in Atexcac and *Fluvicula, Opitutus, Pseudoalteromonas, Pseudomonas* in La Preciosa. This study identifies changes in bacterial composition during the whiting events that occur in the stratified summer conditions in crater lakes La Preciosa and Atexcac.

10-O   Comparison between [^{15}N]-deoxyadenosine method and [^{3}H]-thymidine method for measuring bacterial production in aquatic environments.   *Kenji Tsuchiya [1] - Tatsuki Toda [1] - Tomoharu Sano [2] - Noriko Tomioka [3] - Akio Imai [3] - Nobuyuki Kawasaki [4] - Hideki Fukuda [5] - Koji Hamasaki [5] - Yuya Tada [6] - Shinji Shimode [7]*

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It is essential to measure bacterial production to understand the flux of energy and elements through the microbial food web in aquatic ecosystems. The conventional methods for bacterial production use the incorporation of either tritiated thymidine or leucine into bacterial cells (^{3}H-TdR and ^{3}H-Leu methods, respectively). Although these methods provide methodological simplicity and high sensitivity, the use of radioactive substrates is strictly restricted in field sampling (e.g. at field stations and on research vessels). To overcome these problems, we have developed a new radioisotope-free quantitative measurement of bacterial production using a stable isotope labeled substrate, [^{15}N$_5$]-2'-deoxyadenosine, and a liquid chromatography mass spectrometry (LC-MS) (^{15}N-dA method). Procedures of the ^{15}N-dA method include 5 steps, 1) incubation of water sample with ^{15}N-dA, 2) filtration onto a membrane filter, 3) DNA extraction, 4) enzymatic hydrolysis of DNA to nucleosides, and 5) quantification of ^{15}N-dA amount by LC-MS.

In the present study, results of methods between ^{15}N-dA and ^{3}H-TdR were compared in freshwater lake and coastal ecosystems in order to verify robustness of the ^{15}N-dA method. Freshwater and seawater were collected from Lake Kasumigaura and Sagami Bay, Japan, respectively. The water samples (1.5 to 5 mL) were incubated with 50 nM final concentration of ^{15}N-dA or ^{3}H-TdR. Each sample was incubated at 10, 15, 20, 25 and 30 °C for 5 hours. Incorporation rates of ^{15}N-dA and ^{3}H-TdR were quantified according to the procedures described in Tsuchiya et al. (2015) and Fuhrman and Azam (1980, 1982), respectively.

The ^{15}N-dA and ^{3}H-TdR incorporation rates of freshwater bacteria ranged from 5.5 to 136 pmol dA L^{-1} h^{-1}, and from 24 to 435 pmol TdR L^{-1} h^{-1}, respectively, in the lake. The incorporation rate of ^{15}N-dA was positively correlated with that of ^{3}H-TdR, [^{15}N-dA] = 0.28 × [^{3}H-TdR] − 4.7 ($r = 0.91$, $n = 20$, $p < 0.001$; standard major axis model II linear regression). The 2.5 and 97.5% confidence intervals of the slope were 0.23 and 0.34.

The ^{15}N-dA and ^{3}H-TdR incorporation rates of marine bacteria ranged from 0.62 to 182 pmol dA L^{-1} h^{-1}, and from 0.31 to 321 pmol TdR L^{-1} h^{-1}, respectively, in the bay. As with the results in the Lake Kasumigaura, there was a positive relationship between the incorporation rates of ^{15}N-dA and ^{3}H-TdR, [^{15}N-dA] = 0.55 × [^{3}H-TdR] − 4.1 ($r = 0.99$, $n = 20$, $p < 0.001$; standard major axis model II linear regression). The 2.5 and 97.5% confidence intervals of the slope were 0.51 and 0.58. The results suggested that ^{15}N-dA method can estimate bacterial production with the same precision of the ^{3}H-TdR method, and can be a powerful tool for measuring bacterial production in the aquatic environments.

10-O   Food web study of microbial mats from Byers Peninsula, Antarctica.   *Pablo Almela-Gómez* [1] - *David Velázquez* [1] - *Ana Justel* [2] - *Eugenio Rico* [3] - *Antonio Quesada* [1]

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Cold environments constitute ~85% of the biosphere. Most part of the cryosphere is located in both polar regions, mainly in Antarctica's inlandsis. Environmental characteristics of these regions consists in a reduction of biodiversity, which reaches minimum records in extreme polar regions. In these habitats, microbial communities acquire a fundamental role, showing even higher diversities than in Planet's southern areas. Aquatic communities are mainly dominated by cyanobacteria, diatoms and green algae. These microorganisms, among others, form microbial mats communities, organized ecosystems which develop a close relationship that leads to a dynamic community. In these ecosystems, trophic relationships are established between different microorganisms, setting energy flow and matter circulation.

Here we present the trophic relationships of microbial mats from Byers Peninsula, Antarctica, from the study of stable carbon isotopes ($\delta^{13}C$). Natural abundance values of different groups of microorganisms studied were used as basis for determine their trophic positions, from where two enrichment experiments were conducted in controlled environments. In one hand, by adding directly the inorganic carbon compound labeled, and in the other, by incubating *Chlamydomonas spp*. with this inorganic carbon compound labeled and incorporating later into the microbial mat. These *in situ* incubations were followed by sampling at different times, using variations in the isotopic composition of carbon in each group as tracers through food webs.

Results showed that sources or primary producers, mainly diatoms and cyanobacteria from the upper layer, assimilate inorganic labeled compounds during the first 8 hours, returning to initial values of natural abundance differently. Consumers (rotifers, tardigrades and nematodes) showed very different trophic profiles, given the differences in their eating habits. Rotifers and tardigrades assimilated inorganic labeled compounds for the first 24-48 hours, with differences between large and small tardigrades, while the nematodes did at 11 days, reaching the top of the food web of polar microbial mats. Results obtained from the incubated *Chlamydomonas spp.* addition, showed that they don't represent a native carbon input for the microbial mat, at least during the sampling period that took place during the austral summer, to be at a resistance stage of their life cycle that prevents them from being preyed and/or assimilated.

10-O   Characterization of extracellular dissolved organic matter released by cyanobacteria dominant in a shallow eutrophic lake.   *Akio Imai*

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The accumulation of DOM in lake water certainly influences the way in which lake environmental protection should be managed, because DOM is regarded as a source of organic pollution and, further, as an energy source for microbe-based aquatic food webs. The increase in DOM also presents a serious challenge for drinking-water management since DOM can be a major precursor to carcinogenic trihalomethanes produced during chlorination in water treatment plants.

It is well known that phytoplankton release extracellularly a significant portion of photosynthetically fixed organic carbon into DOM pool in aquatic environments. Extracellular DOM (EDOM) released by the blooming phytoplankton is

likely an important source of the accumulating DOM. In this study, we examined characteristics of EDOM released by three cyanobacteria species in terms of biodegradability, DOM-fraction distribution, and molecular size distribution. Axenic unialgal cyanobacterial cultures of *Microcystis aeruginosa*, *Anabaena flos-aquae*, and *Planktothrix agardhii* were selected, which were isolated from algal blooms in Lake Kasumigaura, Japan. Growth experiments were conducted in batch cultures. Cells were inoculated into 9-L of the modified CB medium in 10-L HCL-washed polycarbonate bottles and grown axenically at $25\pm0.2°C$ and about a photon flux of 100 microE m^{-2} s^{-1} under a light/dark cycle of 12 h: 12 h. About 700 mL of the culture filtrates were inoculated with ca. 1% by volume of the filtrate water of Lake Kasumigaura and was incubated in the dark at 20°C with ca. 60 rpm for 100 days. Recalcitrant DOM (RDOM) was defined as DOM that remained after the 100-day incubation test.

Sample filtrates (DOM) and RDOM samples were fractionated into 5 fractions: aquatic humic substances (AHS), hydrophobic neutrals (HoN), hydrophilic acids (HiA), bases (BaS), and hydrophilic neutrals (HiN). Molecular size distribution of DOM and RDOM samples was also analysed by size exclusion chromatography with the detections of total organic carbon and ultraviolet ray absorption.

Almost all EDOMs released were found to be hydrophilic DOM such as HiA, BaS and HiN. Futhermore, DOM-fraction distribution of EDOM was varied depending on the species and growth phase of cyanobacterium. For the *M. aeruginosa* EDOM, HiA dominated during the exponential growth phase, while HiN did during the stationary phase. On the other hand, almost all *P. agardhii* EDOM was HiA.

The degree of biodegradation also depended on the cyanobacerial species. About 40 to 50% EDOMs of both *M. aeruginosa* and *A. flos-aquae* EDOMs were degraded, while more than 90% of the *P. agardhii* EDOM was.

Two peaks of high-molecular-weight (HMW, ca. 10^5 Da) and low-molecular-weight (LMW, ca. 250 Da) were found in all EOMs. The HMW DOM was increased during the exponential phase, while the LMW DOM was during the stationary phase. The HMW fraction had almost no UV absorbance.

10-O   Hexavalent chromium ion complexation by microbial cellulose.   *Camila G. A. Geromel-Costa* [1] *- Juliano Corbi* [1] *- Wilton Rogério Lustri* [2] *- Silmara Lazarini* [2] *- Regiane Campana* [1]

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The input of heavy metals by anthropogenic sources in aquatic environments occurs mainly by industrial effluent discharge submitted to inefficient treatment techniques. To analyze the potential impacts of heavy metals effects to aquatic biota, the current work studied the effects of hexavalent chromium in the *Chironomus xanthus* larvae, due to define its LC_{50} for 96h contaminant exposition period (acute toxicity test). We also evaluate the sequestering metallic ions through the adsorption by microbial cellulose produced by Gram-negative, aerobic and acetogenic *Gluconacetobacter hansenii*. For acute tests, 10 larvae were added (III instar – 4 d) to 240 mL of test solution in three replicates. The experiments were conducted at room temperature of 23 °C ±2, photoperiod of 12:12 h light/dark with food being added every two days. This cellulose showed very efficient in relation to Cr^{6+} adsorption in metal remotion rates. The removal rate was up 90% when the toxicity was conducted with addition of organic matter for feeding (Tetramin® diluted in deionized water) and with *C. xanthus* larvae. The results points to the viability of microbial cellulose application as metals adsorbent and the outcomes could provide the basis for enabling the use of microbial cellulose in remediation impacts of metals on aquatic contaminated environments.

10-O   Algal vs. non-algal organic carbon as a key nutrient source of bacterioplankton in shallow lakes.

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Dissolved organic carbon (DOC) is a key regulator of aquatic ecosystems, and the primary substrate for numerous aquatic bacteria. The variation in DOC source and composition in aquatic ecosystems, therefore, fundamentally determines bacterial abundance, production and metabolism. Our aim was to study how the source of DOC affects bacterial metabolism in shallow lakes. Bacterial biomass (DAPI staining), production (^{3}H-Leucin incorporation method) and carbon source utilization (Biolog EcoPlate) were investigated in ten shallow lakes within the Carpathian Basin during summer 2015. Dissolved organic matter fluorescence was characterized using a HITACHI F4500 fluorescence

spectrophotometer, while organic carbon forms were measured using an Elementar High TOC analyser. Sampling stations represented a wide range in salinity (electric conductivity between 65 and 18200 μS/cm), pH (4.0 – 10.4), chromophoric dissolved organic matter (CDOM as colour between 3 and 3800 mg/L) and trophic state (chlorophyll a concentration between 2 and 2800 μg/L). Bacterial production ranged between 0.7 and 290 μg C/L/h in the studied water bodies. Carbon source utilization profiles showed different patterns among the lakes. Contrary to large deep lakes, algal and non-algal organic carbon (dissolved coloured or humic substances) were both important nutrient sources for heterotrophic bacteria. However, the importance of the two factors (algal vs. non-algal organic carbon) regulating bacterial production varied from lake to lake. The study was sponsored by OTKA PD112449.

10-O   Interactive effects of temperature and doc sources to carbon stored in the sediment of aquatic ecosystems. *Lúcia Sanches[1] - Adriano Caliman[2] - Bertrand Guenet[3] - Francisco Esteves[1]*

Federal University Of Rio De Janeiro, Federal University Of Rio De Janeiro, Rio De Janeiro, Brazil[1] - Federal University Of Rio Grande Do Norte, Federal University Of Rio Grande Do Norte, Natal, Brazil[2] - Unité Mixte De Recherche Cea-cnrs-uvsq, Unité Mixte De Recherche Cea-cnrs-uvsq, Gif-sur-yvette, France[3]

The sediments of aquatic ecosystems are of great importance in the global carbon cycle and represent a substantial sink. Carbon dynamic in sediments is controlled by several physical and chemical factors such as the temperature, the chemical structure of the organic molecules and the availability of different sources of DOC. In this study we performed a laboratory experiment to investigate the independent and interactive effects of different DOC sources and temperature for the C content in the sediment of aquatic ecosystems. The experimental units were set up in 3 L bottles that were filled with sediment and water from a coastal lagoon – Cabiúnas (22^0 15' S; 41^0 40' O; Macaé – RJ - Brazil). To mimic the inputs of an autochthonous and an allochthonous DOC source we added (i) dried leaves of the most quantitative macrophyte present in Cabiúnas lagoon and (ii) lixiviates of the around terrestrial vegetation. DOC sources were added alone or combined and three different amounts were added: 100gC m^{-2}, 400gC m^{-2} and a control without DOC. Each treatment was incubated at two different temperatures ($25^{o}C$ and $30^{o}C$) during six months in the dark to prevent primary production. Carbon concentration in sediment was measured three times during the incubation: at the beginning after 3 and 6 months. Results were analysed trough a Repeated Measured Anova using DOC source and quantity and temperature as predicted factors and time as the repeated factor. The variation of C concentration between the first and the last measurement in each mesocosm was analysed trough a Factorial Anova with Tukey as post hoc test. C concentration was significantly affect by temperature ($F_{1;24}$ = 12.46; p = 0.002), experimental time ($F_{2,48}$ = 16.41; p<0.0001) and the interaction between both ($F_{3,48}$ = 25.35; p<0.0001). At higher temperature the amount of C decreased significantly between the first and the last measurements for all different treatments of source and amounts of DOC added. Moreover, we observed a net negative balance of C in the sediments at high temperature when macrophyte leaves were added suggesting an interactive affect among higher temperature and authoctonous DOC source. However, such effects were not observed at low temperature. Our results are quite important in the context of climate changes because it suggests that with temperature increase, lagoon sediments might became a net source of C. Furthermore increase in primary production that are also related to future predictions of climate changes can result in higher availability of autochthone DOC to aquatic ecosystem. The majority of autochthone DOC in aquatic ecosystems is labile. The phenomenon of priming effect describes that high availability of labile DOC may increase the degradation of recalcitrant organic matter. Thus our results can also be considered as an indicative of occurrence of priming in aquatic ecosystems.

10-P   Spatial biodiversity of planktonic bacteria in the Yenisei River determined by next-generation sequencing.   *Olesya Kolmakova [1] - Michail Gladyshev [1] - Alexey Rozanov [2] - Sergey Peltek [2] - Maria Trusova [1]*

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The Yenisei River is the longest (4803 km) and has the greatest discharge (636 km^3 yr^{-1}) among all rivers flowing into the Arctic Ocean. For the first time, the bacterial biodiversity in the Yenisei River over the length of about 1800 km was studied using next-generation sequencing of V3-V4 hypervariable regions of 16S rRNA gene and common biodiversity indices. Water samples were collected during a research cruise in June 2012. Ten sampling transects were located

downstream and upstream inflows of major tributaries. At each transect three sampling sites were established: near the left bank, the right bank and in the mainstream. Illumina MiSeq platform was used for paired-end sequencing and QIIME pipeline was chosen for subsequent bioinformatics analysis. Overall 3022 operational taxonomic units (OTUs) of planktonic bacteria belonging to 17 known phyla were identified in the Yenisei River. Actinobacteria and Proteobacteria were the dominant phyla at all sampling sites. The alpha-diversity of bacterial communities and the relative proportion of Cyanobacteria reached maximum values in the middle of the studied section. There were significant differences in ecological parameters between left and right banks at many transects in the Yenisei River, including those of bacterial assemblages. These differences were most likely caused by large right-side tributaries.

There were three bacterial assemblages differing significantly in the OTU composition and inhabiting different parts of the Yenisei River located in the mountain taiga (the upper part of the river), the lowland taiga (middle portion) and the tundra (lower portion). Presumably these assemblages were formed as a result of biogeochemical influence of the surrounding landscape. The dominant taxa of each assemblage specialized in the consumption of various organic substances. The obtained results can be used for integrated environmental monitoring of the Yenisei River and to determine the contribution of the largest Arctic river ecosystem to the global sink of carbon in the biosphere.

10-P   Macrogels in a deep oligotrophic lake: their role in the organic carbon cycle. *Roberto Bertoni , Cristiana Callieri, Mario Contesini. Gianluca Corno , Diego Fontaneto*

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Macrogels such as transparent exopolymer particles (TEP) can be especially significant in freshwaters as in the oceans because they constitute microenvironments that exhibit peculiar physical, chemical, and biological properties. In addition, in inland waters TEP can affect carbon export and sequestration in sediments because they appear to be critical for the formation of particles aggregates. Previous studies show that TEP concentrations can be large relative to the organic carbon pool in both marine and freshwaters. Despite this apparent relevance of TEP for their role as microbial substrate or by product and for carbon export to sediments, no studies exist on TEP in southern alpine large oligotrophic and deep lakes. We started the first extensive analysis on TEP concentrations in Lake Maggiore, where in recent years the presence of TEP become evident, associated to diatoms in spring or as wind accumulated foams. We determined the significance of TEP in terms of carbon in comparison to total organic carbon (TOC), and bacterial and phytoplanktonic carbon. In addition, we explored the persistence in time and space of TEP and the potential influence of biological and chemical factors as drivers of TEP concentrations in the water. Our two-year study showed that in the oligotrophic Lake Maggiore, characterized by low TOC concentration (summer max ~ 1.6 mg L^{-1}), TEP can reach the 36% of TOC in the photic layer never exceeding the 2% in the hypolimnion, below 50 m depth. TEP concentration also exhibit clear seasonal variability mirroring that of phytoplankton, ranging 0-489 µgC L^{-1}.

10-P   Characterization of biological communities (planktonic and microbial) and trophic state of the Atibainha Reservoir, a section of the Cantareira supply system, Brazil.   *Celio Roberto Jonck, Amanda de Souza, Angela Lucia Pantoja Matta, Elizabethe de Campos Ravagnani, Thais Viti, Marcelo Luiz Martins Pompeo*

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The Cantareira is the largest water producer system in the world. Made up of interconnected reservoirs, it is responsible for supplying 55% of the Greater São Paulo. With the ongoing urbanization on the reservoir surroundings also increases concerns about eutrophication, which affect both the supply and the public health. We evaluate the condition of one of the reservoirs of this system, the Atibainha Reservoir.

We collect primary data on water and sediment. In the water, we measure nutrients, suspended solids and chlorophyll a. We also measure physical chemistry parameters temperature, electrical conductivity, pH, dissolved oxygen, turbidity and reduction potential, with a multi-parameter probe. In the sediment, we measured the organic fraction and nutrients. Among the biological variables, we include the characterization of phytoplankton, zooplankton and microbial communites.

We find the elements phosphorus and nitrogen in low concentration. Phosphorus was observed as limiting element for the establishment of planktonic communities. On the other hand, we find highest concentration of chlorophyll than expected. Using a principal components analysis, we found that the water residence time influences the distribution of communities. The stream and the channel 6 clustered influenced by oxygen, nitrogen and turbidity. The channel 5 and the central spot lined influenced by the electrical conductivityand less by the photic zone. Finally, the dam was separated from the remaining spots strongly influenced by pH and temperature.

We find green algae, diatoms and cyanobacteria as main representatives of phytoplankton community. We also find six potentially toxic species among those. Such conditions are consistent with an initial eutrophication process. Regarding the zooplankton, we found high similarity around the reservoir, except for the stream spot that had less richness and different composition. We observe species that indicates eutrophic environments steadily in the reservoir.

The microbial richness supports the clustering seen in the principal component analysis. We saw a considerable number of OTUs (operational taxonomic units) not assigned to specific taxa, indicating the possible presence of a large number of unknown species in the environment. Among the most abundant bacteria we found taxa involved in nitrogen and sulfur cycles and enterobacteria, which supports the hypothesis that the reservoir is in the process of eutrophication.

We conclude, therefore, that the Atibainha reservoir, although still framed as Class I water body (water fit for human consumption after disinfection), is in the initial process of environmental quality degradation by the eutrophication process. As a mitigation measure, we suggest inhibition of population settlement and tertiary treatment of any sewage that are released in the reservoir basin.

10-P   Growth rate regulation in heterotrophic freshwater bacteria – lessons learned from *Legionella Pneumophila*. *Shira Ninio* [1] *- Courtney Marin* [2] *- Ogan Kumova* [2]

The Yigal Allon Kinneret Limnological Laboratory, Israel Oceanographic And Limnological Research, Migdal, [1] *- Department of Microbiology And Immunology, Drexel University College of Medicine, Philadelphia,* [2]

Legionella pneumophila is a heterotrophic Gram-negative bacterium found ubiquitously in freshwater ecosystems. It is a parasite of protozoa and can efficiently replicate inside the cells of a large variety of protozoan species. Permissive protozoa provide a replication niche for the bacteria and are ultimately consumed in the process. *Legionella* is important from a public health perspective because it can cause deadly pneumonia in people that inhale aerosolized water containing the bacteria. *Legionella* can survive in a wide range of environmental conditions where it can be found in association with protozoa, free-living and in biofilm. The transition between these different states is presumed to enable the survival of *Legionella* in complex freshwater ecosystems. In an effort to uncover mechanisms controlling lifestyle decisions in this pathogen, we identified a gene termed *bffA* that contains a signature sequence linking it to the signaling pathway of the second messenger cyclic di-guanosine monophosphate. Here we show that the bffA gene affects biofilm formation, cellular replication, and virulence in *Legionella*. A strain lacking *bffA* has an enhanced biofilm formation phenotype, forming biofilms both faster and thicker than wild type. In addition, the knockout strain has significantly reduced motility and enhanced uptake into amoeba. The mutant shows altered growth kinetics on both solid media and in liquid media. When tested alongside wild type in an intracellular growth competition, Δ*bffA* had a strong advantage. Our data suggests a potential role for *bffA* in signaling pathways that govern changes in growth rate and growth style in response to environmental conditions.

10-P   Possible control strategies for toxic cyanobacterial blooms by using of algicidal bacteria associated with water plants.   *Yohei Miyashita, Senri Kojima, Ichiro Imai*

Division of Marine Biology And Environmental Science, Graduate School of Fisheries Sciences, Hokkaido University, Hakodate, Japan

Many lakes have been suffered from cyanobacterial blooms due to toxic species such as *Microcystis aeruginosa*. Hence, there is an urgent need to control those toxic blooms. Although physical and chemical methods were proposed to apply against them, these were not practical methods because of high costs and serious concerns with environments. Therefore, practical and environment-friendly strategies are crucially needed to control. Recently we found the existence of algicidal bacteria possessing ability to kill the toxic cyanobacterium *M. aeruginosa* on the surface of the submerged stem of the reed (*Phragmites australis*). These bacteria were considered to be environment-friendly agents to control cyanobacterial blooms. Based on this finding, we deduced the existence of that kind of bacteria in the biofilm

on the surface of water plants. Here we report the findings of the algicidal bacteria (**AB**) and growth-inhibiting bacteria (**GIB**) against *M. aeruginosa* isolated from the three aquatic plants *Trapa japonica*, *Myriophyllium verticillatum* and *Utricularia vulgaris*.

Samples of water plants were collected at two sites of Sansui and Junsai-Numa Lake in Ohnuma quasi-national park, Nanae-cho, Hokkaido, during the period of July to October 2012. Collected water plants were put into sterilized bottles with autoclaved distilled water, and bottles were vigorously shaken 600 times to detach the biofilm from the surface of water plants. Algicidal abilities of bacterial strains of colonies were tested with the co-culture experiments using the axenic culture of *M. aeruginosa* (strain Ma17). Algicidal activities and/or growth inhibition of Ma17 were observed and checked with an inverted microscope.

AB against Ma17 were actually confirmed from the water plant *T. japonica* of Sansui in July and August with densities of 2.5 x 10^6 and 3.5 x 10^6 CFU g^{-1} wet leaf.

At Junsainuma Lake, **AB** against Ma17 were counted from the water plant *T. japonica* from July to September with densities of 3.2 x 10^5 to 3.2 x 10^6 CFU g^{-1} wet leaf.

AB isolated from *M. verticillatum* was 2.5 x 10^6 CFU g^{-1} wet weight in July. **GIB** were detected from *U. vulgaris* with densities of 6.2 x 10^6 to 9.2 x 10^6 CFU g^{-1} wet weight in July and August. No **AB** were confirmed from *U. vulgaris*.

Water plants have been reported to possess abilities of nutrient absorption and allelopathic effects to phytoplankton. Algicidal activity and growth inhibition of water plants were newly discovered against the toxic cyanobacterium *M. aeruginosa* by this investigation. Negative relationships were empirically known between the abundances of water plants and phytoplankton in freshwater ecosystems. AB and GIB are thought to play an important role in controlling the occurrences of cyanobacterial blooms in lakes. We propose restoration and/or creation of water plant zones as an effective strategy for prevention and suppression of nuisance cyanobacterial blooms in freshwater ecosystems.

10-P   Prokaryotic picoplankton composition associated with whiting events in tropical volcanic lakes in Mexico. *Arantza I. Daw-Guerrero*, *L. Alberto Vizuet-Martinez, J. Salvador Hernández-Avilés*

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The whiting event is a process in which small calcium carbonate particles are precipitated by changes in different carbon forms concentration likely caused by bacterial activity. Particle accumulation in the surface causes a neon blue colour in the water and a reduction of the euphotic zone depth. Whitings have been observed in different aquatic systems and recently in lakes located in the tropical zone. Furthermore, the occurrence of these processes can be related to global warming and it is strongly linked with the carbon cycle.

The aim of the present research was to evaluate the abundance and composition of prokaryotic picoplankton in volcanic lakes Atexcac and La Preciosa a month before and after and during the occurrence of the whiting event. Bacterial composition was assessed by means of 16S ribosomal RNA CARD-FISH technique, focused on the most important taxa reported in lakes. Whereas autotrophic and heterotrophic picoplankton density and biomass was evaluated through epifluorescence microscopy.

Salinity concentration in hyposaline Lake Atexcac allows a more stable buffer system in comparison to subsaline Lake La Preciosa. In Lake Atexcac a minimum variation was observed in bicarbonate and carbonate concentration during the studied months, being carbonate the dominant ion in the whiting event. Conversely, a strong change in inorganic carbon ions was recorded in La Preciosa. Thus, a high bicarbonate concentration was observed before and after the event, while carbonate concentration increased from 4.84 to 6.34 meq CaCO$_3$ L^{-1} during the event.

In both lakes, the domain *Bacteria* was dominant with hybridization percentages between 42% and 46% while domain *Archaea* showed a low hybridization less than 10% in both lakes.

In both lakes prokaryotic assemblages were dominated by class *Alphaproteobacteria*, including LD12 lineage and *Paracoccus*. The other prokaryotic groups analyzed showed a higher spatial and temporal variation.

During the whiting event *Betaproteobacteria* was the most abundant in Lake Atexcac, and *Gammaproteobacteria* was dominant before the event occurrence. Conversely, an inverse abundance pattern of these *Proteobacteria* classes was observed in Lake La Preciosa. Finally, a bloom of picocyanobacteria wa s observed within the surface layer in Lake Atexcac during the whiting event that was associated with carbonate nucleation due to the capacity of some cyanobacterial groups to improve carbon uptake to perform photosynthesis. Furthermore, in Lake La Preciosa a peak of picocyanobacteria was observed in the metalimnion before the whiting event. In accordance with changes in the prokaryotic assemblages a mechanism is proposed by which bacterial activity, autotrophic and heterotrophic, caused and actively participated in carbonate precipitation; rejecting the possibility that the Whiting event was driven only by inorganic and environmental causes.

12. REMOTE SENSING OF LAKES: STATE OF ART AND FUTURE PERSPECTIVES

12-O   Survival at its best: morphological, ecophysiological and phenological variability of *Phragmites Australis* in Lake Balaton.   *Viktor Tóth*

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Variability of Phragmites australis is often used to explain its cosmopolitan distribution. To gain a better understanding of how the functional traits influence the success of Phragmites, data on variability of morphological and ecophysiological traits and possible factors modulating them are shown using proxy and remotely sensed data. 26 areas in reed stands of western (eutrophic) and eastern (mesotrophic) parts of Lake Balaton including stable (not deteriorating) and die-back (deteriorating) patches of Phragmites were monitored throughout a vegetation period and compared.

Phenology of Phragmites from the western and the eastern parts of Lake Balaton indicated a minor, but substantial difference: plants of the western (eutrophic) part of Lake Balaton reached specific phenological stages earlier than plants from the eastern (mesotrophic) part of the lake. The difference in phenology between these studied parts of the lake was not constant, reaching its maximum of 3.5 day difference in favour of the western areas in the middle of May, and disappearing by the middle of June. The calculated phenological parameters correlated not only with trophic (total and nitrate-nitrite nitrogen), but also with the physical (organic C and clay content) properties of the sediment, while only minor relation with air and water temperature was found.

Comparing phenology of stable and die-back stands indicated significant advantage of the stable Phragmites over die-back plants in shoot development. This manifested in significantly higher (~34%) rates and significantly longer (by 16 days) growth period of stable plants. The differences between the growth of stable and die-back plants were consistent throughout the studied reed stands, i.e. as compared to the die-back stands the plants of the stable sites had higher ecophysiological, morphological parameters, and resulting normalized difference vegetation index (NDVI) throughout the studied stands without any territorial specificity.

This study indicates that sediments rich in nitrogen and clay are associated with quicker growth of Phragmites especially in the first phase of their growth cycle. It was also shown that die-back of Phragmites slows plants phenology significantly. The study showed that UAV platforms are useful tools of wetland monitoring and with proper validation could be used for morphological, ecophysiological and phenological assessments with high spatial and temporal resolution.

12-O   Assessment of primary producers composition, abundance and distribution in Mantua Lakes system from airborne hyperspectral data.   *Monica Pinardi [1] - Paolo Villa [1] - Rossano Bolpagni [2] - Erica Matta [1] - Claudia Giardino [1] - Marco Bartoli [2] - Mariano Bresciani [1]*

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Spectral reflectance data acquired from remote can be effectively used as ecosystem monitoring tools. In this work, we use airborne hyperspectral data to assess composition, abundance and distribution of primary producer communities in Mantua Lakes (Northern Italy), a shallow eutrophic fluvial lake system characterized by the coexistence of phytoplankton and macrophytes. In this context, our main objective is to explore hyperspectral data capabilities for: 1) distinguishing different macrophyte groups (emergent, submersed, floating-leaved and free floating), 2) identifying phytoplankton functional types (PFTs), and 3) analyzing the complex relationships between primary producers and physico-chemical factors (e.g., water temperature, water velocity, solar irradiance, nutrient availability) in the study site. Two campaigns (2011/09/21, 2014/09/27) with the Airborne Prism Experiment (APEX) sensor were performed. For calibration and validation of spectral products, in situ historical dataset (acquired since 2006) and new spectral data were gathered. APEX and in situ data were combined to develop semi-empirical algorithms and spectral inversion techniques (bio-optical modelling) for mapping water pigments - chlorophyll a (chl-a), phycocyanin (PC), and phycoerythrin (PE) - and macrophyte canopy biophysical parameters. The APEX-derived chl-a concentration maps were

based on semi-empiric methods which make use of a 'two-bands adaptive' model (r=0.95) and bio-optical modelling inversion for low chl-a concentrations (r=0.96). Further validation was performed on PC pigments obtained from APEX imagery of 2011 (r=0.93) and of a proxy of PFTs product obtained from 2014 data. In 2011, two cyanobacteria species dominated by PC pigments were relevant in the algal composition. The APEX-derived map of PFTs showed a gradient, consistent with field observations, where diatoms progressively decreased from west to east and contemporarily Chrysophyta and cyanobacteria species dominated by PE increased. Semi-empirical models based on spectral proxies of spectral vegetation indices were used to derive macrophyte canopy parameters maps: i.e. fractional cover (fC) (r=0.94), Leaf Area Index (LAI) (r=0.96), and biomass (r=0.92). These products were analyzed to assess cover, abundance, and spatial variability of macrophyte groups and PFTs, and to investigate the relationships with physico-chemical parameters in the Mantua lakes system.

12-O   Remote sensing of lake carbon dynamics: an evaluation of algorithms for Coloured Dissolved Organic Matter (CDOM).

Maria Encina Aulló Maestro, Peter Hunter, Claire Neil, Evangelos Spyrakos, Pierre Mercatoris, Andrew Tyler

University of Stirling, University of Stirling, Stirling,

There is increasing evidence that lakes play an important role in regional and global biogeochemical cycling, particularly in the storage, transport and transformation of carbon. However, the role of lakes in the global carbon cycle remains poorly constrained and there is much uncertainty about how carbon cycling in lakes is likely to be modified under future climate change. Improvements in our ability to measure and detect changes in carbon storage at large scales are needed if we are to improve our understanding of lake carbon dynamics and its regional and global significance. Remote sensing can provide information on carbon in lakes through, for example, the estimation of absorption by coloured dissolved organic matter (CDOM), a photoactive component and reliable tracer for dissolved organic carbon (DOC).

The recently launched ESA Sentinel-2 MSI and the forthcoming launch of Sentinel-3 OLCI, will provide an improved capability to obtain information on CDOM in lakes at higher spatial and temporal resolutions. However, while many CDOM retrieval algorithms have been proposed, they have not rigorously validated for inland waters and new or modified approaches may be needed to fully capitalise on the potential of the Sentinels and other future satellite missions.

The principal aim of this study is to assess the efficacy of current CDOM algorithms over a wide range of lake optical types. Here we present a first evaluation of CDOM retrieval algorithms incorporating empirical, semi-analytical and analytical approaches, using in situ remote sensing reflectance (R_{rs}) and CDOM absorption (a_{CDOM}) measurements from lakes internationally. The best performing algorithms were then further tested using Envisat MERIS satellite data for selected case study lakes. Finally, this presentation will discuss the implications of this work for remote sensing of dissolved organic carbon in lakes and identify future research priorities.

12-O   Reporting the rapid warming of italian lakes derived from homogenized multi-sensor satellite data.

Sajid Pareeth [1] - Mariano Bresciani [2] - Fabio Buzzi [3] - Barbara Leoni [4] - Fabio Lepori [5] - Alessandro Ludovisi [6] - Giuseppe Morabito [7] - Rita Adrian [8] - Markus Neteler [9] - Nico Salmaso [1]

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Recent studies, using a combination of long term in-situ and satellite data indicate that lakes are warming rapidly at the global scale. Lake Surface Water Temperature (LSWT) being sensitive to long term modifications in the thermal structure of lakes is a good indicator of changes in lake characteristics. Further studies are needed to understand variation in

trends, impacts and consequences at the regional scale. However, long term in-situ data recorded with high temporal frequency are often lacking. Remote sensing is considered a promising approach to reconstruct complete time series of LSWT where direct measurements are missing. Temperature of land/water surfaces is one of the direct and accurate measurement using the satellite data acquired in thermal infra-red spectral region. Furthermore, some measurements are even available since the 1980 at the daily temporal resolution and 1 km moderate spatial resolution. In this study, we aim to i) reconstruct a homogenized LSWT database for six large Italian lakes by combining thermal data from multiple satellites, ii) assess the quality of satellite derived LSWT using long term in-situ data collected from these lakes, iii) report the seasonal and annual trends in LSWT using robust statistical tests.

We compiled the LSWT database using daily data spanning 29 years (1986 - 2015) at a spatial resolution of 1 km, time standardised to 12:00 UTC using a new methodology, which combine data from multiple sensors. We used dual thermal channels (10.5 – 11.5 μm and 11.5 – 12.5 μm) and a split window algorithm with sensor specific coefficients to derive LSWT. We calibrated the thermal data acquired by six sensors on-board thirteen satellites and corrected them geometrically before deriving the LSWT. The sensors used for this study were (satellites in bracket) – AVHRR/2 (NOAA-9/11/12/14), AVHRR/3 (NOAA-16/17/18/19), ATSR1 (ERS-1), ATSR2 (ERS-2), AATSR (ENVISAT) and MODIS (AQUA/TERRA). We applied a modified Diurnal Temperature Cycle (DTC) model to correct the LSWT for different acquisition time of the satellites.

Using this new LSWT dataset we are studying the long-term annual and seasonal trends in the peri-alpine lakes - Garda, Iseo, Como, Lugano, Maggiore, and the Lake Trasimeno in Central Italy. We found good agreement between LSWT and in-situ data with an average R^2 and RMSE of 0.90 and 1.5 K, respectively. With regard to seasonal and annual trends, in Lake Garda, surface water mean temperature showed a significant (**P < 0.05) increase with annual rate of 0.013 ºC yr^{-1} and of 0.03 ºC yr^{-1} during summer (Kendall tests and Theil-Sen's slope estimates). The statistical analysis of other lakes are in progress and these results will allow us to evaluate further the accuracy of the LSWT reconstructed using satellite data and assess the regional coherence of the trends detected in lake Garda.

12-O   Combination and comparison of airborne and satellite remote sensing data for assessment of lake chlorophyll-a concentrations and water level changes: the case study of Lake Burtnieks, Latvia.

Dainis Jakovels , Agris Brauns, Jevgenijs Filipovs, Juris Taskovs, Gatis Erins, Matiss Zagars

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Regular monitoring of lake chlorophyll-a (chl-a) concentrations and water level fluctuations is necessary for sustainable water resource management and is usually performed by field surveys. *In situ* measurements are accurate, but spatially and temporally limited. Remote sensing techniques can provide data with good spatial and temporal resolution - the possibility to monitor a single lake of interest or several waterbodies simultaneously and analyse historical data from the last 20 – 30 years. Extraction of water quality parameters as well as data on water level changes are among the main remote sensing applications for ecological assessment of water bodies. More complex approaches include also assessment of macrophytes and land cover of the catchment basin.

In this study, we present a combination and comparison of airborne and satellite remote sensing data for ecological assessment of Lake Burtnieks in Latvia. Airborne data were acquired in summer 2014 and consisted of hyperspectral (400-2500 nm spectral range), topographic LiDAR and high resolution (10 cm/pixel) RGB aerophoto data. The acquired data were combined with concurrent field survey information. The combined information was then used to correlate the chl-a field measurements with optical data and water level measurements with water mask obtained from LiDAR and satellite data. Landsat satellite data (26 scenes) from last 30 years were used for monitoring of chl-a concentrations, water level changes and macrophyte cover dynamics. Comparison of high resolution airborne and moderate resolution satellite data products was also performed to test algorithm transfer. Results showed good agreement between chl-a remote sensing data products and in situ observations providing insight into non-uniform spatial distribution of algal bloom. Lake water cover masks obtained from terrain model and water level *in situ* measurements correlated well with water cover masks obtained from satellite spectral data. Remote sensing data products were also evaluated for further use in lake management and ecological scenario modelling.

12-P   Methods and tools for assessing impacts of saharan dust deposition in Lake Garda from remote sensing data.   *Ilaria Cazzaniga, Mariano Bresciani, Claudia Giardino, Anna Rampini*

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Mineral dust aerosol is generated by Aeolian erosion of soil in desert areas. Due to its origin, it is rich in nutrients and trace metals (e.g. Fe, Si, Al, Mg) useful for phytoplankton growth. Several studies show dust deposition in oligotrophic stratified waters, could induce algal blooms. They have been conducted on oceans and Mediterranean Sea waters, and remote lakes, exploiting Remote Sensing data and techniques. These techniques allow in fact a frequent collection of data with a synoptic point of view on the study area, at relative low costs. In the activities of LTER CNR Sirmione station and SINOPIAE project framework, the effect of dust deposition was inspected on deep clear meso-oligotrophic Lake Garda.

For this analysis, different optical satellites images (e.g. MERIS, MODIS) were exploited to retrieve chlorophyll-a concentration (chl-a), proxy of phytoplankton abundance: a processing chain for the retrieval of chl-a values was calibrated and validated. Chl-a is in fact retrieved through empirical or bio-optical models exploiting water reflectance. This physical quantity is not directly measured by sensors, but it can be retrieved from their products through the removal of the atmospheric contribution to the signal and other disturbing factors (e.g. specular reflection and adjacency effect). For MERIS imagery, this operation has been conducted through BEAM-C2R Neural Network, which allows the retrieval of both reflectance and chl-a values, while for MODIS and LANDSAT imagery, 6SV and bio-optical model BOMBER were used.

Aerosol parameters retrieved by AERONET sunphotometers in Northern Italy (the last one installed in 2014 in Sirmione) were exploited for both image atmospheric correction and dust deposition events individuation. Aerosol can in fact be characterized by some optical and physical properties (e.g. AOD, refractive index, particle size distribution) which allow to infer their origin.

Once the events had been individuated, chl-a concentration in the time-window comprising each deposition event, was analyzed.

To assess the actual contribution of deposition to possible chl-a increase, other influencing factors were analyzed (i.e. temperature, to which phytoplankton growth is positive correlated, precipitation, which could induce both wet deposition and the run-off of nutrients previously deposited along the coast). For this purpose an user friendly interface was realized to allow easy identifying anomalies in chl-a from time series of chl-a maps. In particular, the tool allows classifying waters on the basis of some chl-a threshold based on WFD criteria, identifying anomalies in chl-a long time series and evaluating the area where dust deposition could have mainly affected chl-a anomalies, considering both temperature and precipitation.

Further progressions of this study include the validation of a new processing chain for the new-generation sensors, Sentinel-2 and Sentinel-3, from which some preliminary results are thus presented.

14. EXPERIMENTAL LIMNOLOGY: FROM MICROCOSMS TO IN-LAKE INTERACTIONS

14-O   Interactions between submerged rootless and floating plants: competition and facilitation, the role of perifiton.   *Sandor Szabo* [1] *- Zoltán Nagy* [2] *- Tibor Tamás Vicei* [1] *- Gergő Koleszár* [1] *- Gábor Borics* [3]

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Both floating and submerged rootless vegetation can form stable dominance in small water bodies like ditches and ponds world wide. However those interactions that may reveal how either of these group can sustain it's stable dominance has not investigated experimentally. Floating (*Lemna gibba*) and submerged rootless (*Ceratophyllum demersum*) plants were co-cultured in various combinations in aquaria containing static and semi static media under wide range of nutrient concentration (0.2-10 mgN L^{-1}) with the presence and absence of the benthic grazer snail *Radix labiata*.
Experiments showed that *Ceratophyllum* was able to sustain it's dominance against Lemna if only the nutrient loading was not extremely high. *Ceratophyllum* strongly limited the growth of *Lemna* under lower nutrient range.   Periphytic algae grown on the surface of *Ceratophyllum* was related to growth limitation of Lemna by 20%. The biomass of periphyton was reduced by 90% due to the grazer snail Radix labiata and consequently increased the growth both for *Lemna* and *Ceratophyllum*. Consequently grazer snail weakened the competitive impact of periphyton on *Lemna*.
Under intermediate nutrient concentration, the sub-dominant *Lemna* cover stimulated the growth of *Ceratophyllum*. However above 2 mgN L^{-1}, Lemna over grew *Ceratophyllum* and performed it's stable dominance. The transitions between the submerged rootless and the floating plant dominated states were well indicated through pH and dissolved O$_2$ concentration of the water. Results strengthen the hypothesis that submerged rootless vegetation can prevent colonization of lakes by floating plants and the latter group becomes dominating exclusively in hypertrophic conditions.

14-O   Is strict nitrogen control a must to mitigate eutrophication?   *Hongzhu Wang, Haijun Wang, Yan Li, Qing Yu, Xucheng Xiao*

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In the field of eutrophication control, there exists a heated debate over the necessity of nitrogen (N) reduction besides phosphorus (P) reduction for a long time. Long-term whole-lake fertilization experiments in subarctic Experimental Lakes Area (ELA) of Canada and lake restoration practices in some high-latitude areas have demonstrated that P reduction alone can mitigate eutrophication. However, such large-scale evidence is little in warmer climatic zones. In this study, whole-ecosystem fertilization experiments were conducted in subtropical ponds (ca. 500 m^2 for each, in the middle Yangtze River Basin) to test the idea that N reduction cannot control the amount of total phytoplankton effectively (8 ponds and 18 months) and to test the toxicity of high N on aquatic organisms at moderate phosphorus concentrations (10 ponds and one year). The results showed that: 1) The amount of total phytoplankton in treatment -N+P (N reduction alone) was similar to or even higher than that in +N+P (none reduction) and both were much higher than that in -N-P (dual reduction), demonstrating that N reduction cannot control the amount of total phytoplankton; 2) TN in -N+P increased to a relatively high level along with the appearance of N-fixing cyanobacteria, indicating that N deficiency could induce massive growth of N-fixers and hence maintain high TN; 3) The amount of total phytoplankton showed no obvious difference between +N-P (P reduction alone) and -N-P and both were lower than that in +N+P, demonstrating that P reduction alone could effectively control total phytoplankton; 4) Submersed macrophyte *Vallisneria natans* (Lour.) Hara was not influenced when TN was lower than 12 mg L^{-1}, a level much higher than most eutrophic lakes; 5) Three species of cyprinid fish grew well in ponds when exposed to NH$_3$ as high as 96 h LC50 obtained by acute toxic test in lab condition. These findings suggest a strategy of "loosen N control and focus on P abatement". Such a strategy is of practical importance since the cost of eutrophication mitigation can be greatly decreased.

14-O   Silent visitors – effects of non-successful invaders on freshwater phytoplankton community dynamics. *Felicitas Buchberger, Maria Stockenreiter, Herwig Stibor*

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Species invasion dynamics are a core topic in ecology and the effects of species invasions on ecosystems are well described. However, the knowledge about the mechanisms during the invasion process itself is limited. Many interactions between invaders and resident species occur during the invasion process. Theses interactions influence individual species abundance and subsequently community composition. Functional traits, which are characteristic for each species potentially, determine the outcome of a successful invasion. However, invaders are often unsuccessful, but even the very short interaction with the resident species may have influence on species abundances and therefore community composition. In theoretical models of invasions in microbial food webs it was shown, that these unsuccessful invaders (so called ghost species) can have prominent effects on the community composition. To test empirically the effect of such ghost species on a resident phytoplankton community, we conducted a mesocosm experiment in an oligotrophic freshwater pond. Six freshwater algae of three functional groups (chlorophyta, cyanophyta, bacillariophyta) were added as invaders to the natural phytoplankton community of the pond. After nine days the invasion success and the impact on the natural phytoplankton community was estimated. Results show that all invaders were ghost species and did not establish after invasion. However, these ghost species had lasting effects on the resident community. In all invaded treatments the biodiversity was increased and different influences on the resident community dynamics were obtained, depending on the invading algae species. Our results can be used to predict shifts in resident phytoplankton community composition after a non-successful invasion, depending on the characteristic traits of the invader.

14-O   Phosphate-fertilization and CO_2-addition have complementary effects on phytoplankton: a mesocosm experiment. *Karl-Otto Rothhaupt, Dietmar Straile, Dominik Martin-Creuzburg, Elizabeth Yohannes, Hilmar Hofmann, Frank Peeters*

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Despite being an essential resource for primary producers, inorganic carbon is oftentimes not considered as a mineral nutrient. This is presumably due to the anthropocentric (or zoocentric) habit of calling mineral nutrients all elements that are required by organisms, except those that make up the bulk of organic matter (C, H, O). The availability of inorganic carbon for primary producers may change, as atmospheric CO_2 levels are expected to double or triple by the end of the century (IPCC 2007). Traditionally, phosphorus is presumed to be the most important limiting nutrient in pelagic food webs of lakes. We designed and performed a mesocosm experiment to investigate the single and combined effects of phosphate- and CO_2-additions on plankton communities. We hypothesized a sequential limitation of phytoplankton growth, first by P and then by CO_2, and that CO_2-addition would primarily affect the taxonomic composition.

The experiment was performed in fall 2015 and it consisted of 12 plastic bags (600 L volume each) that were filled with phytoplankton-containing water, obtained from Lake Constance, that had been screened through 100 µm gauze. On the first day, 300 adult laboratory-bred adult *Daphnia magna* were added to each bag. We had 4 treatments with 3 replicates each: unfertilized controls, P-fertilized bags, C-fertilized bags and bags receiving both nutrients. P-fertilized bags received an initial phosphate pulse of 100 µg P/L; C-fertilized bags received a continuous supply of gaseous CO_2 via a diffuser, which resulted in about 4-fold increased CO_2-concentrations. The experimental duration was 18 days. Samples were taken twice a week.

P-fertilization resulted in rapid initial phytoplankton growth and led to high phytoplankton biomass and phosphate depletion in the first half of the experiment. In the second half of the experiment, high *Daphnia* densities developed in the P-fertilized treatments and phytoplankton biomasses fell back due to grazing. The dynamics were less pronounced in the treatments without P-fertilization, where phytoplankton and *Daphnia* densities remained low. Contrary to our expectation, there was no clear effect of CO_2-addition on the taxonomic composition of the phytoplankton. Most importantly however, simultaneous CO_2-addition and P-fertilization revealed complementary effects. With the supplementary addition of CO_2, phytoplankton growth and phosphate depletion occurred noticeably faster than in the merely P-fertilized treatment. The vigorous phytoplankton growth became also apparent in oxygen supersaturation that developed in bags receiving both nutrients.

In conclusion, rising atmospheric CO_2 levels may interact with conventional mineral nutrients to aggravate the implications of eutrophication.

14-O Changes in light dependency of pelagic metabolism of a tropical lake under manipulated nutrient, DOC, and light conditions.   *Peter Staehr [1] - Ludmila Brithenti [2] - Luciana P.M. Brandão [2] - Denise Tonetta [3] - Francisco Barbosa [2] - Jose Bezerra-Neto [2]*

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We conducted a factorial mesocosm experiment in a tropical lake to investigate how additions of inorganic nutrients and allochthonous organic matter (OM), and shading affect rates of gross primary production (GPP), respiration (R) and net ecosystem production (NEP). Nutrients, chlorophyll (Chl) and OM were monitored every three days during 15 days. Daily metabolic rates and related light response parameters were calculated from high frequency dissolved oxygen data using an inverse modelling approach. Light response parameters enabled us to determine daily measures of photo-inhibition and light limitation of GPP. Nutrient additions raised the magnitude and day-to-day variability in both GPP and R resulting in positive NEP, compared to additions of OM which made the systems more net heterotrophic. Although shading by 50% reduced photo-inhibition, primary production was never strongly light limited. Normalizing GPP to phytoplankton biomass (Chl) indicated higher light utilization efficiency in the low nutrient, low Chl treatments. Additions of nutrients strengthened the coupling between GPP and R and OM additions elevated the background respiration levels. Our results support recent evidence of strong interactions between nutrients, OM and light conditions both for the magnitude, variability and coupling between GPP and R in tropical lakes.

14-O Plankton community response to P-enrichment and N-imbalance: a mesocosm experiment in a P-limited lake.   *Aitziber Zufiaurre [1] - Marisol Felip [2] - Pau Giménez [3] - Lluís Camarero [4] - Sergi Pla [1] - Jordi Catalan [3]*

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High nitrogen deposition has shifted many mountain lakes to marked P-limitation during the last decades, although increased P deposition may be partially reversing the situation in some places. How these P-enrichments or the modification of N-imbalance modify the planktonic communities is largely unknown. We carried out a mesocosm experiment to test the effects of different degree of P and N enrichment in a P-limited lake in which time series have indicated a progressive reduction in the N:P imbalance (Lake Redòn, Pyrenees). Dissolved inorganic nitrogen (DIN) was added in two different forms (NH_4^+, NO_3^-) to test for differential effects. Ten different treatments were performed, with two replicates for each and two control mesocosms. The mesocosms consisted in 20 m-long transparent cylindrical bags with sediment traps at the bottom and vertically deployed in the epilimnion of the lake for three weeks in summer. Remarkably, the replicates respond in a very similar way. Variation in species growth patterns and community composition were observed in both P-enrichment and N-imbalance treatments and varied for some species depending on the DIN forms. Changes related to P-enrichment were high, whereas only a part of the community responded to N-imbalance, without an apparent biomass effect in the entire community. The increase in biomass with P-enrichment resulted in a change of the main autotrophic groups. At high enrichments chrysophytes and dinoflagellates decreased and chlorophytes increased. However, when considering individual species, there were some of them not following the same response as most of the group. For instance, chrysophytes showed a negative response to an increased N-proportion, however, some of them responded to NH_4^+ and others to NO_3^-. The heterotrophic part of the community followed the same pattern as autotrophs in the P-enrichment treatments, increasing their abundance. However, the response in the N-imbalance was the opposed. The main groups of heterotrophs increased their abundance with higher N additions. These results will be highly useful for the interpretation of the seasonal and long-term changes observed in these lakes. In these time series, in addition to nutrients, other factors are simultaneously changing, so that revealing the precise role of nutrients on community variation from them is not straightforward.

14-O   Role of predator and resource control on biological communities in the naturally eutrophic, subarctic Lake Myvatn, Iceland.

Sandra Brucet [1] - *Miguel Cañedo-Argüelles* [1] - *Serena Sgarzi* [1] - *Ignasi Arranz* [1] - *Xavier D Quintana* [2] - *Zeynep Ersoy* [1] - *Frank Landkildehus* [3] - *Torben L. Lauridsen* [3] - *Árni Einarsson* [4] - *Erik Jeppesen* [3]

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The relative importance of predator and resource control in lakes has been extensively debated. Lakes in the Arctic and subarctic are most often oligotrophic and species-poor. In such lakes, fish predation effects on consumers tend to be particularly strong. Some lakes in cold environments are however naturally mesotrophic or eutrophic, and it is unclear to what extent fish can influence the trophic structure and dynamics in these systems. To study the role of fish on the trophic cascade of lakes, we conducted a 3 month *in situ* controlled experiment in the naturally eutrophic, subarctic Lake Mývatn using three-spined sticklebacks (*Gasterosteus aculeatus* L.) as top predators. Our results indicated that both top-down and bottom up forces are important for structuring the communities in lake Mývatn and that their relative importance changes over the summer and differs among the different trophic levels. Fish predation affected zooplankton and phytoplankton densities and sizes during the first weeks but in August a bloom of *Anabaena* overrode the fish cascading effect. The effect of fish predation was strongest on plant associated macroinvertebrates and lasted over the summer. A warming climate may cause an increase of stickleback activity either due to direct effect of warmer temperature or due to the reduction of the population of its predator Arctic char which could lead to a more intense tropic down control on zooplankton in lake Mývatn.

14-O   What does the term 'nutrient limitation' mean when managing cyanobacteria?: a case study using the toxic species *Cylindrospermopsis raciborskii.*

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The term, nutrient limitation, is a commonly used in ecology to determine cyanobacterial responses to nutrients. However, it is often poorly defined and oversimplifies physiological responses of cyanobacteria to nutrients. We studied the concept of nutrient limitation using the toxic nitrogen-fixing cyanobacterium, *Cylindrospermopsis raciborskii* in a gene-to-ecosystem approach. Our studies in the laboratory and field showed that this species is highly adapted to low nitrogen and phosphorus concentrations and have developed strategies to dominate under these conditions. This includes a high storage capacity for nitrogen and phosphorus, at the expense of higher growth rates, and use of energetically expensive mechanisms, such as active phosphorus uptake and organic phosphorus utilization. These strategies allow *C. raciborskii* to reach bloom proportions despite the seemingly nutrient limiting conditions. Nutrient concentrations and ratios provide an inadequate measure of the potential for *C. raciborskii* blooms, and the term, nutrient limitation, has little meaning in an ecological context. We propose that studies of responses of cyanobacteria to nutrients should focus on techniques and approaches that more accurately reflect the complexity of responses to nutrients.

14-O   Hypolimnetic enclosures: a new tool to study internal phosphorus cycling and hypolimnetic oxygen depletion under changing climatic and trophic conditions in lake.

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Oxygen conditions and internal phosphorus (P) cycle in lakes are mainly influenced by processes during and after sedimentation. Detailed information about the location and rates of these processes are necessary (1) to predict internal P cycle and oxygen consumption under changed loading and climate conditions, (2) to understand the linkages between oxygen and P release, and (3) to select optimal management measures against eutrophication. To quantify P release

and oxygen consumption during and after sedimentation separately, we installed a new type of enclosure in the dimictic, highly eutrophic Lake Arendsee (maximum depth 49.5 m), NE Germany. Long term observations of this lake over forty years have shown that the hypolimnetic P concentration increased faster than the epilimnetic P one. Additionally, the water volume depleted in oxygen is extending and a distinct metalimnetic oxygen minimum has been formed in recent years. During last four decades, the duration of summer stratification has increased by about 20 days. The novel mesocosm facility consists of eight 30 m long polyethylene laminated enclosures with a diameter of 3 m. Thus, the enclosed water can be in contact with the sediment surface and receives newly settling material. These enclosures hang below a platform at the deepest site of the lake. The results of the enclosure experiments were interpreted mainly using a mass balance approach based on frequent measurements of vertical profiles inside and outside the enclosures. Our contribution will present first practical experiences with the installation and sampling of hypolimnetic enclosures, quantification of enclosure artefacts and results of the first experiments. Following manipulations were tested: (1) Prevention of P release from sediments by addition of a P binding chemical (Phoslock®) near the sediment or by a mechanic barrier, and (2) exclusion of sedimentation by capping the enclosures. Comparing the manipulated enclosures with control enclosures and with the water column outside the enclosures enables us to quantify the impact of sediments on P release and oxygen consumption in comparison to freshly settled organic seston. We could show that oxygen is mainly consumed in the water column (by the heterotrophic activity of sinking aggregates and by reduced substances) whereas P is mainly released from settling particulate P after sedimentation. Additionally, the enclosures were successfully tested to simulate meromictic conditions by prolonging the stratification period and to generate pelagic redoxclines with a several meter thick anoxic water layer by exposing the enclosures in the metalimnion.

14-O   The advantage of mixotrophy under phosphorus limitation.   _Monika Poxleitner_ [1] - _Gabriele Trommer_ [1] - _Maria Stockenreiter_ [1] - _Herwig Stibor_ [1]

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Increasing nitrogen loads can affect ecosystem dynamics in various ways. In nitrogen limited systems, fertilizing effects of an increased nitrogen supply and thus an increase of primary producer biomass are predictable. However, also in phosphorus limited systems influences of increased nitrogen availability could be expected due to increasing phosphorus limitation. In phosphorus limited pelagic systems effects of nitrogen enrichment on phytoplankton community composition and stoichiometry are potentially possible.
Within phytoplankton, mixotrophic species can respond in a different way to nitrogen enrichment compared to purely autotrophic species as they can additionally use particular phosphorus sources such as bacteria. Mixotrophs might therefore be less affected by increased phosphorus limitation and could outbalance potential shifts in stoichiometry and growth.
In a field mesocosm experiment in a P-limited, oligotroph, temperate lake we could observe a biomass increase of the mixotrophic chrysophyte _Dinobryon divergens_ with increasing nitrogen enrichment. Additionally, seston stoichiometry was less affected by the nitrogen enrichment despite strong shifts in the ratio of dissolved nutrients. In order to further investigate those effects we tested possible advantages of mixotrophy under increasing nitrogen supply conditions. In a laboratory experiment _Dinobryon sp._ (mixotroph) and _Scenedesmus obliquus_ (autotroph) were grown in nitrogen enrichment gradient under presence and absence of a natural bacteria community. We analysed algal growth and stoichiometry in response to the nitrogen enrichment and compared the performance of algae cultures in the presence and absence of natural bacteria communities.

14-O   Periphyton support for littoral secondary production in a highly humic boreal lake revealed by stable isotope additions.   _Jussi Vesterinen_ [1] - _Jari Syväranta_ [2] - _Shawn Devlin_ [3] - _Roger Jones_ [1]

The Department of Biological and Environmental Science, University of Jyväskylä, Jyväskylä, Finland [1] - _Department of Bioscience, Aarhus University, Silkeborg, Denmark_ [2] - _Flathead Lake Biological Station, University of Montana, Polson, United States_ [3]

Small humic lakes tend to be steeply stratified with very shallow oxic layers restricting the suitable habitats for invertebrates. While the pelagic can be dominated by zooplankton, oxic littoral areas are restricted to lake edges near the surface. These littoral habitats can have highly productive periphyton assemblages and relatively rich invertebrate communities. Food web structure and diets of these invertebrate communities are poorly known. Studies of coupling

of pelagic and littoral through the movement of fish or zooplankton between these habitats have mostly concerned rather clear lakes and relatively little is known about pelagic-littoral coupling in highly humic lakes.

We used stable isotope analysis to investigate the diets of littoral invertebrates and possible pelagic-littoral coupling in Mekkojärvi, a small highly humic and fishless lake in southern Finland, which has dense population of cladoceran *Daphnia longispina* in the pelagic. The littoral consists mainly of a floating moss mat surrounding the lake edges, which hosts highly productive periphyton communities and a more diverse macroinvertebrate community than the pelagic. We added ^{15}N-labeled ammonium nitrate to the littoral moss mat several times during the open water season in 2014 in order to label the periphyton. During our study Mekkojärvi was divided in two with a plastic curtain and European perch (*Perca fluviatilis*) was introduced into one basin while the other remained fishless. We expected periphyton would take up the ammonium nitrate quickly but the label would not spread into the pelagic phytoplankton, allowing us to investigate the importance of periphyton in invertebrate diets and to track the movement of the label within the littoral taxa and possibly between the littoral and pelagic habitats in two treatment basins, fish present and fish absent.

$\delta^{15}N$ of periphyton increased well above the natural abundance levels and most of the littoral invertebrates also showed greatly increased $\delta^{15}N$. Pelagic *Daphnia* showed no significant increase in $\delta^{15}N$, except for a sudden high peak soon after the fish introduction. Of 33 captured perch, only one showed increased $\delta^{15}N$. The lowest $\delta^{13}C$ values were analyzed from pelagic invertebrates while most of the littoral invertebrates had values closer to periphyton, apart from chironomids and Ephemeroptera which had surprisingly low $\delta^{13}C$ values. Highly ^{13}C-depleted methane oxidizing bacteria are known to contribute to the diets of *Daphnia* in the lake and might also account for the low $\delta^{13}C$ of some littoral invertebrates. Our results indicate that the pelagic and littoral habitats are not coupled in the absence of fish but may become so if zooplanktivorous fish are introduced, driving zooplankton into the littoral to seek refuge. Highly productive periphyton seems to contribute to invertebrate diets and represents an important basal resource in the littoral.

14-O   Size-based interactions within the food web of Lake Mývatn, Iceland: a mesocosm experiment.

Zeynep Ersoy [1] - Erik Jeppesen [2] - Serena Sgarzi [1] - Xavier D. Quintana [3] - Ignasi Arranz [1] - Miguel Cañedo [1] - Frank Landkildehus [4] - Torben L. Lauridsen [2] - Árni Einarsson [5] - Sandra Brucet [6]

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Body size structure of organisms may be affected by several biotic (i.e. predation, competition) and abiotic factors (i.e. nutrient concentrations). Fish predation is one of the key factors affecting size structure of planktonic communities. Planktivorous fish feed on large-sized zooplankton, causing small-sized zooplankton dominate the system and their effect may cascade to the phytoplankton level. In order to investigate the cascading effects of fish predation on the size structure of zooplankton and phytoplankton, a mesocosm experiment was conducted in Lake Mývatn, Iceland during summer of 2014. The experiment was composed of eight circular enclosures with two fish (*Gasterosteus aculeatus*) treatments (with fish- and without fish) and four replicates for each treatment. Chemical and biological samples (phytoplankton and zooplankton) were taken weekly. By using parameters of size spectrum (slope, intercept and coefficient of determination) and size diversity, we studied changes in the size distribution of zooplankton and phytoplankton communities. Our results show that zooplankton size structure was driven by fish predation and by changes in individual sizes along time, whereas it was not affected by planktonic resources because no relationship was found with phytoplankton size structure or total biomass. Moreover, according to our results, fish predation decreased the size diversity of zooplankton community which became dominated by smaller individuals. In contrast, phytoplankton size structure changed along time mainly driven by changes in resources. Phytoplankton size diversity increased with increasing productivity. The increase in the slopes of the phytoplankton size spectrum (i.e. flatter spectra) along time indicates the blooms of large-sized algae. Overall, our results indicate that both top down and bottom up controls, as well as the seasonal changes in species composition, influence the size distribution of planktonic communities of Lake Mývatn.

14-O   Field experiments to directly measure turbulence from vertically migrating zooplankton in lakes.   *Stefano Simoncelli [1] - Stephen Thackeray [2] - Danielle Wain [1]*

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Bio-turbulence (or bio-mixing) refers to the contribution of living organisms towards the mixing of waters in oceans and lakes. Laboratory experiments in unstratified tanks indicate that small zooplankton can trigger fluid instabilities through collective motions that are larger than the individual organisms (Wilhelmus and Dabiri, 2014), although other experiments in unstratified (Noss and Lorke, 2012) and stratified tanks (Noss and Lorke, 2014) have concluded that while turbulence may be enhanced, there is little net mixing of fluid (i.e. the eddy diffusivity is low). Very recently, Wand and Ardekani (2015) showed a maximum eddy diffusivity of 10^{-5} m^2/s (two orders of magnitude above molecular diffusion of hear) for millimetre-sized organisms from numerical simulations in stratified fluid.

These previous numerical and laboratory experimentation provide contradictory evidence for the role of small zooplankton in mixing stratified lakes, partially because of the challenges of replicating the natural swimming behaviour of zooplankton in the lab. To address this gap, a field experiment is being conducted in Vobster Quay (UK), a small (500 m), deep (40 m), wind-sheltered, former quarry, which has an abundant *Daphnia spp.* population. This very common species is engaged in a vertical migration (DVM) at sunset, with many organisms crossing the thermocline, the sharp temperature gradient in the density stratification. During the ascension they may create hydrodynamic disturbances in the lake interior where the vertical diffusion is usually suppressed by the temperature stratification. The research aims to directly measure the temperature fluctuations and kinetic energy dissipation rate generated by DVM. A tracer experiment is also planned to experimentally measure the diffusion coefficient during the ascension to compare the results and its importance with the well- known mixing mechanisms in lakes due to wind and internal waves. The quarry characteristics allow us to uniquely isolate turbulence and mixing from migrations from these other sources.

14-O   Effects of stocked trout on native communities in mesotrophic lakes: insights from mesocosms, a whole-lake BACI manipulation, and a natural experiment.   *William Tonn, Justin Hanisch, Cynthia Paszkowski, Garry Scrimgeour, Leslie Nasmith*

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Stocking of non-native trout can have serious negative effects on native communities. Effects have been especially strong in alpine and oligotrophic lakes, but it is unclear how trout affect native communities in other, e.g., more productive, lakes where stocking frequently occurs. To investigate this, we first conducted a "natural experiment", comparing prey populations (forage fish and macroinvertebrates) and food webs among a suite of stocked and unstocked lakes in the foothills of Alberta, Canada. Subsequently, we combined a Before-After Control-Impact (BACI) manipulation at the whole-lake scale with experimental mesocosms to determine and understand how (or if) stocked trout affected the ecology of prey in these lakes.

There were no demonstrable differences in the abundance of forage fish between stocked and unstocked lakes, although forage fishes in stocked lakes occupied vegetated inshore areas to a greater extent, and were more crepuscular and concentrated on the lake bottom. The natural experiment similarly detected no clear negative effects of introduced trout on invertebrate community composition and few taxa-specific examples of decreased or increased invertebrate abundance or size-selective predation.

In our BACI study, habitat use of mobile taxa (forage fish and macroinvertebrates) changed little in the "impact" lake after stocking, and few differences in the overall structure of food webs were observed after stocking or in stocked relative to unstocked lakes. In unstocked lakes, forage fishes generally occupied the highest trophic position, occasionally joined by leeches. In stocked lakes, trout typically had the highest δ^{15}N, but often overlapped with forage fishes. Food webs of stocked and unstocked lakes also showed similar strong linkages to littoral carbon.   In a fully-crossed mesocosm experiment with natural and reduced densities of macrophytes and forage fish present or absent, invertebrate taxa responding to the treatments were more abundant at natural macrophyte density and/or fish were absent.

Our integration of a natural experiment, a whole-lake BACI manipulation, and mesocosm experiments allowed us to address the question of trout effects in these more productive foothills lakes. Because the naturally high densities of macrophytes that characterize these lakes provide ample refuge for forage fishes and macroinvertebrates, and because stocked trout use resources already exploited by high densities of forage fishes, trout appear to exert relatively small

additional predation pressure on the invertebrate prey base, i.e., forage fishes "pre-condition" invertebrate populations to fish predation. The absence of a significant effect of trout on food webs of our productive lakes provides further evidence that these lakes are able to absorb a new fish predator are better candidates for stocking than lakes lacking these features.

14-P Effects of cylindorspermopsin containing cyanobacterial crude extract on growth, phosphate-uptake and phosphatase activity of the planktonic green alga *Scenedesmus obtusus.*   *Dalma Dobronoki* [1] *- Viktória B-Béres* [2] *- Gábor Vasas* [3] *- Sándor Gonda* [3] *- Sándor Alex Nagy* [1] *- István Bácsi* [1]

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The role of allelopathy in the interactions of phytoplankton populations and the assumption that cianobacterial toxins can be considered as allelopathic compounds are still unanswered questions of phycology. Cylindrospermopsin (CYN) is the best known and the most studied cyanotoxin after microcystins, although there is only a few information about its possible role in algal assemblages and about the biological factors, which influence its production. According to the few literature data, we assumed that one possible role of CYN is forcing other phytoplankton species in the environment to produce alkaline phosphatase (APase), than the cyanobacterium takes up the enzymaticaly liberated phosphate. In this study, cultures of the planktonic green alga *Scenedesmus obtusus* were treated with crude extract of the CYN producer cyanobacterium *Chrysosporum (Aphanizomenon) ovalisporum*. Responses of the green alga in phosphate limited environment were also investigated. The results justified the assumption: CYN content crude extract induced the alkaline phosphatase activity of treated cultures of the studied cosmopolitan green alga, which is not sensitive either to the relatively high CYN concentration or to phosphate limitation. It was confirmed, that CYN may contribute to the phosphate supply of the producer organism with activation of APase secretion of other phytoplankton species. To answer the question, that this phenomenon can be connected exclusively to the presence of CYN, or other compounds are also involved, requires further experiments.

14-P Periphyton development in Vrutci Reservoir: cumulative effect of environmental factors and *Planktothrix rubescens* bloom.   *Ivana Trbojevic* [1] *- Dusan Kostic* [2] *- Ana Blagojevic* [1] *- Sladjana Popovic* [3] *- Dragana Predojevic* [1] *- Gordana Subakov-Simic* [1] *- Prvoslav Marjanovic* [2]

Faculty of Biology, University of Begrade, Belgrade, Serbia [1] *- Jaroslav Cerni Institute For Development of Water Resources, Institute For The Development of Water Resources (jci), Belgrade, Serbia* [2] *- Institute of Chemistry, Technology And Metallurgy, Department of Ecology And Technoeconomics, Belgrade, University of Belgrade, Belgrade, Serbia* [3]

Cyanobacterial blooms have become a common phenomenon in freshwater ecosystems all over the world, violating functioning and limiting exploitation of these ecosystems for water supply and recreation. Reservoir Vrutci is a multipurpose waterbody located in western Serbia, where since December 2013 when first surface bloom occurred, *Planktothrix rubescens* (De Candolle ex Gomont) Anagnostidis & Komárek has been constantly recorded. It's been proclaimed earlier that both taxonomic and non-taxonomic periphyton characteristics are sensitive to cyanobacterial bloom. Artificial substrates in periphyton surveys are accepted as practical and reliable approach, since using it reduces blurry effect of factors such as microhabitat conditions and colonization time, so environmental pulses can be transparently monitored. The objectives of our study were to identify environmental factors determining periphyton characteristics and to explore the effect of *P. rubescens* distribution and bloom in Vrutci reservoir on periphyton development. Artificial substrate samplers were deployed in Vrutci reservoir on site near the dam, using floating platform made out of wooden frame and Styrofoam filling, about 3 square meters area, for manipulating samplers and for carrying them. Four separate samplers made of Plexiglass were deployed on depths – 1m, 5.5m, 8m and 12m. Every sampler consisted of 4 plates with glass slides in triplicates, and monthly from July till October one plate incubated from the start of the experiment was removed and transported to the laboratory where dry mass, ash free dry mass and chlorophyll a were measured. From July till September, new and labeled plates with glass slides were introduced in every sampler subsequently to be sampled next month, after only one month incubation period, parallel with ones

incubated permanently. *P. rubescens* biomass was estimated from phytoplankton samples. Physical characteristics of the water column were measured in situ, and samples were taken for subsequent chemical analyzes. In general, all measured non taxonomic periphyton parameters, from both permanently and monthly incubated slides correlated in between, and environmental factors that likely influenced periphyton biomass appear to be dissolved oxygen (DO), pH, temperature (T) and conductivity (Cond). In July, maximum *P. rubescens* biomass was detected in metalimnion, and this was followed by phenomenon - formation of calcium carbonate coating on glass slides incubated in 5,5m depth. Encountering *P. rubescens* surface bloom in September, drastic decrease of periphyton biomass was recorded in epilimnion, suggesting negative influence of *P. rubescens* spreading over the water column on periphyton biomass. Periphyton development in Vrutci reservoir was influenced mainly with DO, pH, T and Cond, but response to *P. rubescens* presence was apparent, leading us to further investigate this issue.

14-P   Quantifying phytoplankton responses to an experimental gradient of macrophyte abundance and nutrient press.

Jennifer Barrow [1] - *Beatrix Beisner* [2] - *Alessandra Giani* [3] - *Isabelle Domaizon* [4] - *Irene Gregory-Eaves* [1]

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Nutrient concentrations and macrophyte abundances in shallow lake ecosystems are thought to be key factors affecting phytoplankton community structure and abundance. Previous research shows that macrophytes create habitat diversity and support water clarity by inhibiting phytoplankton growth via increasing sedimentation, nutrient absorption, allelopathy, and acting as refuges for herbivorous zooplankton. On the other hand, phytoplankton can inhibit macrophyte growth via shading and competition for available nutrients. Our experiment was designed to answer the following key questions: (a) how does the abundance of macrophytes alter the phytoplankton community structure in response to nutrient press treatments, (b) how does the functional composition of phytoplankton change in response to nutrient enrichment in the presence or absence of macrophytes, and (c) do experimental ponds with high macrophyte abundance have more stable phytoplankton communities compared to mesocosms with low or no macrophyte abundance. For the latter two questions, the majority of work to date has relied on field surveys where little may be known about site history. Our experimental ponds, seeded with natural communities of phytoplankton, zooplankton and fish, allowed us to control and monitor the ecosystems over 12 weeks. Treatment combinations of 3 levels of macrophyte abundance and 2 of nutrient loading were each replicated in 3 experimental ponds. Water samples from each of the 18 ponds were collected weekly for nutrient, phytoplankton and zooplankton analyses. Daily measurements of temperature, conductivity, chlorophyll *a* and pH were also performed. Phytoplankton data were examined for taxonomic and functional trait responses, using redundancy analyses (RDA) to test the prediction that a greater amount of variation in assemblage data could be explained by functional groups. We will also conduct a principal response curve analysis to identify which taxa and/or functional traits were most responsive to experimental treatments. Beta-diversity analyses quantifying community assemblage stability will be performed to test the hypothesis that the high macrophyte abundance-low nutrient loaded ponds would show the smallest amount of turnover through time. Overall, our goal was to provide greater insight into the mechanisms structuring planktonic communities in shallow waters, helping to lay groundwork for stronger predictions regarding the susceptibility of macrophyte-rich shallow lakes to undergo abrupt transitions to phytoplankton dominated states.

14-P   Effect of field environmental variables on bacterivory by mixotrophic flagellates in oligotrophic shallow lakes.

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INIBIOMA - CONICET, Universidad Nacional del Comahue, San Carlos de Bariloche, Argentina [1] *- Instituto De Investigaciones Biotecnológicas- Instituto Tecnológico de Chascomús, CONICET-Universidad Nacional de San Martín, Chascomús, Argentina* [2]

Mixotrophy usually dominates bacterivory in oligotrophic aquatic environments. Mixotrophic organisms could be differentiated along a spectrum of nutritional strategies according to the contribution of bacterivory to their growth. The bacterivory rate of different mixotrophs could be affected differentially by the environmental conditions, like

temperature, nutrient concentrations or bacterial abundance. We analyzed the bacterivory rates of different mixotrophic flagellates (MF) under different natural field conditions along an annual period. A total of eight grazing experiments were performed in two oligotrophic shallow lakes of North Patagonia (Argentina), where the phytoplanktonic community is dominated by MF. Short-term grazing experiments were run in triplicate using fluorescently labeled bacteria (FLB). Bacterivory rates were estimated for each MF taxa. The CSGR (cell-specific grazing rate) varied from 0.21 to 6.74 bact. flag.$^{-1}$ h^{-1}. *Pseudopedinella* spp. were the most bacterivorous MF in both lakes and their CSGR (avg. 3.6 bact.flag^{-1}h^{-1}) were significantly related to the bacterial abundance, a functional response typical of heterotrophic organisms. *Chrysochromulina parva*, *Ochromonas ovalis*, *Dinobryon divergens* and *Cryptomonas erosa*, showed similar CSGR (between 0.52 and 2.79 bact. flag.$^{-1}$ h^{-1}). *O. ovalis* and *C. erosa* showed a negative relationship between CSGR with water temperature and total dissolved phosphorus concentration. The lowest CSGR was estimated for *Plagioselmis lacustris* (avg. 0.62 bact.flag^{-1}h^{-1}), which showed a negative relationship with the total dissolved nitrogen concentration. The negative relations found between CSGR and nutrient concentrations support the premise that phagotrophy could be related with the acquisition of limiting nutrients. The specific ingestion rate, in percentage of the cell carbon ingested per day (%C d^{-1}) decreased with the predator size, thus, smaller flagellates tended to ingest a higher % of C related to its size than larger ones. Interestingly, *Pseudopedinella* spp. were always situated above the regression line of this relationship, while *P. lacustris* was always situated below. Our results suggest that along the spectrum of nutritional strategies of the MF found in this oligotrophic condition, *Pseudopedinella* spp. should be considered as the most heterotrophic flagellates, and on the other side of the gradient, *P. lacustris* should be placed as one of the most autotrophic species.

15. MODELS FOR THE MANAGEMENT OF LAKES AND RIVERS

15-O Assessing the metabolic rates of eight hemiboreal lakes with high-frequency measurements and bayesian modelling.   *Fabien Cremona*, *Alo Laas, Peeter Nõges, Tiina Nõges*

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We employed a Bayesian model for assessing the metabolic state of eight Estonian lakes representing the eight lake types according to the European Union Water Framework Directive. Model input parameters were in situ high-frequency measurements of dissolved oxygen, temperature and irradiance. Model simulations were conducted for several diel cycles for each lake, during the summer season. Taking into account uncertainty, the results revealed that three lakes were autotrophic for the whole duration of the experiment, one was heterotrophic, and four were balanced or had an ambiguous metabolic state. A strong coupling between primary production and respiration was observed. Contrary to what had been described previously, the share of autochthonous primary production respired by consumers was greater in eutrophic lakes than in oligotrophic ones. Unlike gross primary production, community respiration was strongly related to light extinction, dissolved organic carbon (DOC) and nutrient-related variables. These findings suggest that a drastic decrease in light-limited primary production along the DOC gradient counter-balanced nutrient supply in the darker lakes and thus blurred the relationship between primary production and nutrients.

15-O Predicting critical transitions in lakes: theory, application and reality.   *Stephen Ives* [1] *- Linda May* [2] *- Sarah Burthe* [2] *- Peter Henrys* [3] *- Kate Heal* [4] *- Alex Elliott* [3] *- Bryan Spears* [2]

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Regime shifts have been characterised in a number of ecosystems but nowhere as well as in shallow lakes. The non-linear transitions observed between algae and macrophyte dominated states have become a subject of intense research over the last 20 years.   Statistical methods capable of providing early warning of transitions involving the analysis of variance and autocorrelation have been developed mainly using simulated or experimental data. However recent tests using long-term monitoring data from well-known lakes have been less encouraging with low levels of agreement between early warning indicators (EWIs) and detected tipping points. We report, here, on the application and analysis of outputs from EWIs run on the Loch Leven long-term dataset (>40 years of data covering 100s of determinands) including abundance of indicator organisms across multiple trophic levels as well as testing EWIs on a known regime shift using real-world monitoring data. Using these techniques we focus on accuracy and practical application for the potential management of lakes.

15-O Towards an integrated hydrodynamic, water quality, and ecological modelling approach for Lakes Ijssel and Marken.   *Menno Genseberger*

Deltares, Delft, Netherlands

For lakes IJssel and Marken, two big shallow lakes in the Netherlands, various societal aspects are of importance:
- safety assessment of dikes,
- operational forecasting of flooding,
- improving water quality and ecology,
- salt intrusion and drinkwater quality,
- maintenance of navigation channels.
Despite the diversity of aspects, they are related to common underlying physical and biological processes like wind driven waves, suspended sediments, and mussels. We will show with several illustrative real-life applications that deal with these aspects, how hydrodynamic, waterquality, and ecological modelling plays a central role.
Here we mention two applications:

1) For water safety near the lakes, a system is in operational use, enabling real-time dynamic forecasting of wind driven waves, flow of water, and wave overtopping at dikes. From a meteorological model, wind predictions are obtained. From measurements and model predictions boundary conditions are generated for river inlets of the lakes. Then shallow water models of the lakes are applied for modelling the water flow. A spectral wave model computes the wind driven waves. In its turn, wave characteristics are input for calculation of overtopping at the dikes. Both input, throughput, and output data of models and measurements are easy accessible via the graphical user environment of the system.

2) For lake Marken, high suspended sediment concentrations result in reduced ecological values and prevent goals and standards from being met (Water Framework Directive, Natura 2000). Mainly due to wind driven waves (fine) sediment particles on the bed are resuspended and transported by hydrodynamic flow. High concentrations of suspended sediment particles generally result in low transparency values. Light on the bottom is important for waterplants to grow, gradients between clear and turbid water are important for fish-eating waterbirds to get food. A practical measure that is currently studied is the construction of wind-sheltered areas in the North West part of lake Marken. Construction of dams, islands, and shallow areas will influence the physical processes to improve water quality and ecological state. The study of the required size, shape, and location of the structures is being carried out.

For application 2, the major knowledge of physics and ecology is in a coupled silt and Habitat model for ecological impact assessment of lake Marken. Wind driven waves and hydrodynamic flow are in common with application 1.

In the near future, we aim for an integrated approach in which common components for modelling the underlying processes are used for different applications. We will show how we work towards this aim by a step by step approach.

15-O   External versus internal nutrient loading and its impact on management plan of a shallow lake in temperate zone.   *Ryszard Gołdyn, Renata Dondajewska, Katarzyna Kowalczewska-Madura, Natalia Kuczyńska-Kippen, Anna Kozak*

Department of Water Protection, Adam Mickiewicz University, Poznan, Poland

Shallow lakes in Poland are highly vulnerable to eutrophication process due to their natural features as well as agricultural character of their catchment areas. Phytoplankton blooms deteriorate water quality and limit recreational benefits. Raczynskie Lake in Western Poland is typical shallow lake suffering advanced eutrophication symptoms, therefore was an object of thorough research in 2015 aiming at the assessment of water quality and both, external and internal nutrient loading. Management plan was set according to the collected environmental data.

Raczynskie Lake (surface area 84.4 ha, max. depth 5.8 m, average depth 2.7 m) is fed by eight small tributaries, mainly of periodic character and by rainwater runoff from part of Zaniemysl village. Total catchment area drained by those watercourses covers *ca* 280 ha. Phosphorus (P) load in 2015 was 42.5 kg a^{-1}, while nitrogen (N) load reached 336 kg a^{-1}. However, 2015 was exceptionally dry; therefore the loads estimated for typical year increased to 81.1 kg a^{-1} P and 858 kg a^{-1} N. The estimated load entering the lake through shoreline (spatial pollution) was 280 kg a^{-1} P and 5835 kg a^{-1} N. The assessment of internal P loading from bottom sediments was based on experimental research using intact sediment cores, collected in four seasons from two research stations, representing two parts of the lake with different depths. The mean P loading from the shallower part was 2.8 mg m^{-2} d^{-1} P, while from the deeper part it was 6.4 mg m^{-2} d^{-1} P. Hence, the total annual internal loading was 933 kg a^{-1} P. Together with external P loading the total amount reached 1213 kg a^{-1} and it was covered in 77% by the internal loading. This phenomenon was especially important during summer, when catchment impact was lower and internal loading increased due to higher temperature stimulating organic matter decomposition. The lake response to high nutrient loads manifested in low water transparency, decreasing in summer to 20 cm, very high chlorophyll-a content (up to 250 mg m^{-3}), resulted from intense phytoplankton bloom. It was dominated by cryptophytes in March and cyanobacteria from July till October, e.g*. Planktothrix agardhii, Aphanizomenon gracile, Sphaerospermopsis aphanizomenoides* and *Cylidrospermopsis raciborskii*, posing a threat by the harmful toxins excretion. The improvement of water quality in Raczynskie Lake was forecasted. The most suitable seem to be restoration technics, aiming at the decrease of P internal loading. As the content of organic matter in bottom sediments is high (35%), the sustainable restoration measures are proposed like P inactivation using iron treatment with low doses of iron sulphate. Application of innovative product SINOBENT is also recommended. Other less invasive methods, as biomanipulation and submerged macrophyte reintroduction, should support the inactivation process. They should be complemented by the use of methods decreasing external loading of nutrients with tributaries.

15-O   Interpreting long-term variation in biological communities persistence and stability in rivers of Southern Ontario, Canada.   *Almudena Idigoras Chaumel [1] - David G. Armanini [2] - Adam G. Yates [3]*

Prothea Group S.r.l., Universidad Autonoma De Madrid, Milan, [1] *- Prothea Group S.r.l., Western University, Milan,* [2] *- Western University, London (Ontario),* [3]

Riverine bioassessment relies on the assumption that temporal variability in biological data is well understood, yet this assumption has often remained untested. Inter-annual variability of macroinvertebrate community persistence and compositional stability was studied over a period of 15 years (1997-2011) in eight impaired streams in southwestern Ontario, Canada, subjected to anthropogenic water quality pressures and temporally variable hydrological regimes. Regional Mann-Kendall tests were performed to identify directional trends in the biological and environmental data. Biological data were associated with hydrological, chemical and climatic data to quantify the relative importance of key environmental drivers of year-to-year variation among invertebrates. A substantial amount of inter-annual variability was observed for community persistence and compositional stability with large values of annual turnover. Few directional temporal trends were observed in either the biological community or hydrological data, whereas water temperature increased, and Nitrates and Total phosphorous decreased over time. Partial Least Squares (PLS) modeling revealed relationships between variation in several hydrological and water quality variables and the benthic community. The combination of high community turnover and modest biota-environment associations might suggest that taxonomic composition shows a wide range of stochastic variation through time rather than being strictly driven by environmental drivers. While taxa substitution occurs normally in disturbed streams, the underlying causes of such turnover are difficult to determine creating uncertainty as to community resistance to future disturbance. In addition, the lack of strong relationships between the environmental factors and the benthic community composition in our studied streams has implications for the statistical stability of traditional ecological assessment methods for impacted rivers.
Overall, temporal variability appeared to play a relevant role in shaping the benthic community sampled with this specific standard biomonitoring protocol. This paper suggests that the sources of temporal variability and the implications on the evaluation of ecological condition should be understood in the bioassessment of river and streams. Recommendations on how to address temporal variability are discussed.

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15-O   Modeling nutrients residual load from the combined sewer serving the eastern shore of Lake Iseo. *Marco Pilotti* [1] *- Giulia Valerio* [1] *- Steven Chapra* [2] *- Laura Barone* [1] *- Matteo Balistrocchi* [1]

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Combined sewer systems are facilities that collect both sanitary wastewater and storm water in conveyance systems and bring them to a waste water treatment plant. When high intensity rainfalls occur, the treatment plant intake capacity may not be sufficient to handle the high flows, so that overflow discharge weirs (OW) allow a portion of the untreated wastewater and storm water to flow directly into the receiving water body. Over the last decades peripheral sewer systems have been introduced in many lakes in the world in order to reduce observed eutrophication impacts. However, in many cases the recovery was not as evident as expected. Probably this could be due to the pollutant residual load from the OWs, whose importance for public health and environment is sometimes underrated. On the contrary, there is a growing awareness in the scientific community that this occasional and usually unmonitored contribution can significantly impair the quality of the receiving water bodies.
The present work is designed to quantify the nutrient load entering Lake Iseo from the overflows of the peripheral combined sewer serving the eastern shore of the basin during rainy periods. The process of eutrophication, started in the 1980s, has determined the actual critical quality status of the lake's waters, characterized by anoxic conditions and a high level of phosphorus in the deep hypolimnion. Although the peripheral combined sewer system which collects water to two large water treatment plants was completed 13 years ago, the status of the lake has improved less than expected, in terms of average phosphorus concentration.
In order to model the functioning of the mixed sewer system, the Storm Water Management Model SWMM was calibrated. The analysis of the measured data provided evidence of the significant contribution of groundwater infiltration, the level of which is controlled by the lake. Accordingly, clean water enters the sewer with a non-linear progression with the lake water stage. At the same time, a reverse process can probably be expected during dry periods. The calibrated model was used to evaluate the efficiency of the network during the period 2005-2014. Simulations were performed considering the rainfall series. According to the simulations, 26% of the rainy hours and 40% of rainfall events trigger the activation of the OW*s*. The volume of mixed water discharged directly into Lake Iseo is on average 864,600

m^3; i.e., 13% of the flow entering the collector. From the analysis of pollutant concentrations, both Total Suspended Solids and the BOD during some rainfall events exceeds the limits of concentration imposed by regional law RR n. 3/2006. Accordingly, this model provides a rational basis to take into account the residual nutrient contribution to the lake and for the design of management solutions for mitigating the sewer's OWs impact. Finally, an OW monitoring campaign is currently under way and discussed in the contribution.

15-O   Self-automated and heuristic approaches to characterization and prediction of limnological features in Great Lakes. *Kim Dong-Kyun [1], Yuko Shimoda[1], Aisha Javed[1], Shan Mugalingam[2], Friedrich Recknagel[3], George B. Arhonditsis[1]*

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We introduce a new paradigm to data analysis to the Great Lakes research. Most ecological data exhibit a variety of problems, including abnormal distributions (multimodality), non-linearity, many zeros (species abundance), multi-collinearity, and other complex data interactions (spatiotemporal autocorrelation). Nonetheless, many modeling strategies have relied on conventional statistical methods, despite the obvious violations of their assumptions. Machine Learning offers a new type of inductive, data-driven strategy. The ever-growing information, triggered by recent technological advancements of data collection, has made compelling the adoption of such heuristic algorithms to support the decision-making process in environmental management. We demonstrate two Machine Learning techniques used in the Bay of Quinte, Lake Ontario. Self-Organizing Maps are applied to characterize phytoplankton's dominant patterns according to ambient physicochemical conditions in the bay. Evolutionary Algorithms are also used for time-series water quality forecasting of plankton dynamics. Both methods are proven to be robust for non-linear ordination, classification, and rule discovery through data-learning processes. We discuss the prospect of using these techniques in the context of risk analysis and eutrophication management.

15-O   A GIS approach to forecasting dissolved natural organic matter in lakes.   *Ståle Haaland [1] - Bjørnar Eikebrokk [2] - Nils-Otto Kitterød [1] - Gunnhild Riise [1] - Rolf D. Vogt [3]*

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The concentrations of dissolved natural organic matter (DNOM) has increased significantly in many lakes in Scandinavia and Scotland over the past few decades. Applying GIS technology represents several promising potentials for forecasting DNOM concentrations in such lakes. The main potential lies in that GIS incorporate spatial data information. This is essential in regards to understanding the temporal fluctuations in DNOM as it captures the spatial distribution of rainfall-surface runoff and air temperature.

As an example, digital elevation maps (DEM) enables the appointment of water flow-paths during rainfall events, and hence comprises the information required to forecast the main soil compartments contributing to runoff and thus the type of allochtoneous input one might expect from the catchment. This is demonstrated by using a 10x10 m precision DEM grid to distribute rainfall into different flow paths contributing to the runoff. Surface runoff is modelled using a D8 kinematic surface wave runoff algorithm. The demonstration reveals how surface runoff patterns would evolve if a rainfall is applied only above 400 m a.s.l., compared to if the same amounts of rain is added to the same catchment from 50 m a.s.l. and above. This is similar to a radar forecast implementation, in which the same amount of rain (with the same quality) is precipitated, but with a spatially different distribution pattern. The substantial point in this perspective is that in regards to DNOM, conceived in an endmember context, the runoff would differ substantially between such two events. In addition, the effect of the spatial temperature distribution inside a catchment is shown by a second example.

Temperature is of great importance as it governs not only the phase of water (snow, ice cover and melt), but also since it affects primary production and degradation processes. By implementing a GIS approach, we can implement future climate forecasts to predict spatial trends in a DNOM development. This is demonstrated by extracting average data from ten global climate models and the average of three regional climate models (EU Prudence project), data from the Norwegian meteorological institute (DNMI) and the IPCC scenario A2. The precipitation and temperature data have been further downscaled using Gaussian process regression statistics, along with the DEM m a.s.l. data within the catchment. Existing large scale relationships between an increase in air temperature and the response regarding

concentration of DNOM in Nordic lakes, have been adopted to forecast future changes in DNOM concentration in a Norwegian lake.

This study was conducted as an integral part of the NOMiNOR project (www.mn.uio.no/kjemi/english/research/projects/nominor/).

15-O   Relationship between distribution of eurasian otter (*Lutra lutra*) and stream health assessment indexes in Nakdong River, South Korea.   *Sungwon Hong , Youngmin Kim, Ji Yoon Kim, Yuno Do, Gea-Jae Joo*

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For the Last 3 decades, Eurasian otter (*Lutra lutra*) has been protected by law and received great attention from the public in South Korea. However, systematic research on their distribution and role in stream ecosystems has not been fully investigated. Since 2006, the Stream Health Assessment Program (SHAP) has been established in all stream and river ecosystems throughout South Korea ($99,720km^2$). We hypothesized that high values for the four SHAP indexes (Diatom, Micro-invertebrate, Fish, and Habitat assessment) could indicate good habitat for the otter population than other variables.

We investigated otter distribution for 600m transects at 250 sites in Nakdong River basin ($23,800$ km^2) by walking along the riparian zone counting the spraint density in spring 2014. We defined three categories of otter population, i.e. absent, rare and abundant based on spraint density. Comparing density to landscape, topographical features, and the SHAP indexes, we identified critical variables which explained the prescribed grouping using Kruskall-Wallis test.

Otter population were recorded in 195 of 250 investigated sites. The spraint density which explained rare and abundant was 0.016 (No. spraint per meter). The population is affected by anthropogenic impacts (population density, and urbanization). The group with the highest density was found at higher altitude and low areas near water. The Benthic Micro-invertebrate community Index easily explained otter habitats when compared to the other indexes including BOD as well as presence and absence differences. With the Fish Assessment index, the proportion of tolerant species (%) is important, as compared to the abundance and richness of the fish community.

In conclusion, otter habitat is best described by stream health assessment indexes for monitoring, since for the best sites the otter population will have become well established.

15-O   Short-term dynamic forecast of dissolved oxygen concentration with a simple metabolic model and bayesian learning.   *Mark Honti, Vera Istvanovics*

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Hypertrophic shallow lakes show vivid fluctuations in dissolved oxygen (DO) concentration in summer due to the high and frequently unbalanced throughput of ecosystem production and respiration. Low DO levels cause numerous water quality problems related to increasing internal loading, enhancement of anaerobic processes and toxin production, as well as fish-kills; therefore, prevention of such conditions is a meaningful management requirement. Fishponds and urban lakes are often hypertrophic, yet they are typically in the size where water quality can be operatively managed in the time scale of hours to days. In such cases the short-term forecast of critical water quality events can provide an early warning in due time.

While automated DO measurements are becoming widespread, high-frequency data are rarely used for short-term forecasts. Forecasting models should be able to reproduce the typical circadian pattern in DO and be able to adapt to the ever changing ecosystem metabolism. These requirements can be fulfilled by e.g. coupling a simple conceptual model of lake metabolism to a Bayesian learning procedure.

The City Park Lake in Budapest (Hungary) is a small (8000 m^2) urban lake that is fed by the effluent of a nearby thermal spa. The lake is hypertrophic due to nutrient inputs from the groundwater used to cool the thermal water in the spa and a large resident stock of waterfowl. With a mean depth of 1 m and an average hydraulic residence time of 32 hours, the lake could be efficiently managed to prevent low DO events. Water is warm and stratified throughout the year as the inflow (30°C) rolls on top of a cooler layer towards the outflow weir, which reduces the rate of oxygen supply to the deeper layer.

An automatic monitoring pod was deployed in the lake, measuring DO and water temperature at 2 depths every minute. Surface light conditions were characterized by registering the output voltage of the solar cell that powered the station. The model has analyzed the last 24 hours of data with parameter priors originating from the preceding posteriors. After learning the current posterior distributions for the metabolic parameters, a probabilistic forecast was made for the next 24 hours. Two options were used for meteorological boundary conditions: (i) in a "hindcast" attempt the actual temperature and light (voltage) data were used, (ii) in a "real" forecast attempt live weather forecasts were applied. The results show that this dynamic forecast system makes useful predictions for water management and can serve as an early warning system.

15-P   Spread of aquatic invasive species by currents in the great lakes.   *Raisa Beletsky [1] - Dmitry Beletsky [1] - Edward Rutherford [2] - Jennifer Sieracki [3] - Jonathan Bossenbroek [3] - Lindsay Chadderton [4] - Marion Wittmann [5] - David Lodge [5]*

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Knowledge of aquatic invasive species dispersal is important to inform development of surveillance and response strategies and management efforts to slow the spread of established invader. We studied potential dispersal of invasive Eurasian Ruffe and golden mussel larvae in Lakes Michigan and Erie using a three-dimensional particle transport model. Ruffe is currently in northern Lake Michigan, while golden mussel has not yet invaded the Great Lakes. We predicted larval transport from several major tributaries and ports that are most prone to invasion because of their significant recreational and commercial usage. Golden mussel dispersal was larger than that of Ruffe due to stronger seasonal currents, longer drift period, longer spawning times and greater available settlement habitat. Settlement areas for offshore releases were generally larger than that of nearshore releases, and larger for Limnoperna than for Ruffe. Our modeling effort demonstrates that larvae advection by lake currents is an important mechanism of dispersal for non-native species in the Great Lakes.

15-P   Shifts of radiocesium vertical profiles in sediments and their modelling in Japanese lakes.
Takehiko Fukushima, Eiji Komatsu, Hiroyuki Arai, Koichi Kamiya, Yuichi Onda

Faculty of Life and Environmental Sciences, University of Tsukuba, Tsukuba, Japan

Vertical profiles of radiocesium concentrations were measured for the sediment cores taken several times after the Fukushima nuclear accident 2011 in several Japanese lakes with different morphological and trophic characteristics in order to investigate the sedimentation-diffusion processes in lake sediments. In the lakes of which sediments had high porosities and suffered considerable wave actions due to the shallowness, we observed rapid penetration of radiocesium to a certain depth just after the accident and downward movement of the leading edges; in contrast, gradual downward transfers of distinct peaks were found in other types of lakes. A one-dimensional differential sediment model with water-sediments interaction processes was constructed to describe the vertical shifts of radiocesium considering the initial penetration related to sediment water content, deposition based on influent suspended solids, physical mixing due to wave actions, and physico-chemical mixing due to diffusion of desorbed radiocesium from sediment solids in pore waters. The desorption process was described using the ammonium and potassium ions concentrations. The traces of global fallout of radiocesium by nuclear weapons during 1950-1963 were also used to evaluate the simulation results of vertical profiles of radiocesium. The way to develop a generalized sediment model near the surfaces of sediments was discussed with the future challenges.

15-P   Modifying the assessment protocol for the implementation of the aquatic life criteria (DO) in reservoirs of Puerto Rico.   *Gustavo Martinez [1] - David Sotomayor [2] - Luis Perez [2]*

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In 1986 the United States Environmental Protection Agency (USEPA) adopted 5mg/L as the minimum allowable dissolved oxygen (DO) concentration in the nation's waters as a measure to protect aquatic life. At the time USEPA did not established a precise protocol to assess compliance in lakes and reservoirs which has resulted in much confusion on the part of States and Territories on the implementation process. For instance, in Puerto Rico the assessment process is based on a comparison of average DO concentrations obtained at three discrete depths, namely: 1m, 5m, and 15m with the DO criteria. Since tropical lake/reservoirs are naturally prone to developing hypolimnion anoxia during most part of the year said assessment protocol has resulted in all reservoirs being indistinctly classified as impaired regardless their trophic status. A practical (yet scientifically rigorous) approach is needed to separate the effects of nutrient overenrichment from those related to the natural dissolved oxygen (DO) dynamics of tropical lakes/reservoirs. Herein, we propose an alternate assessment protocol based on the relationship between different indicators of reservoir productivity (e.g., nutrients, Chl-*a*, Secchi depth) and the maximum depth of compliance with the aquatic life criteria *(i.e., max depth with DO ≥ 5mg/L)*. Profile data obtained from 14 reservoirs of the island suggests that, under stratified conditions as those prevailing in tropical reservoirs, an ecological threshold (compliance depth threshold) can be defined based on those relations to account for the effect of nutrient overenrichment on the extent of hypolimnion anoxia development. This approach may be useful in other tropical waters provided that the influence of abiotic factors (wind, thermal stratification patterns) on DO dynamics does not vary significantly between the target population.

15-P Assessing the recovery potential of an eutrophic lake with an ensemble of two ecosystem models, PCLake and ECOPATH.   *Aigars Lavrinovičs [1] - Ivars Putnis [2] - Bärbel Müller – Karulis [3] - Matīss Žagars [1]*

Institute for Environmental Solutions, -, Priekuli, Latvia [1] - Faculty of Biology, University of Latvia, Riga, Latvia [2] - Baltic Sea Centre, Stockholm University, Stockholm, Sweden [3]

Human use of natural resources – e.g. agriculture, forestry, peat mining – can degrade aquatic ecosystems by eutrophication. Lake Burtnieks, a shallow lake in Latvia, is an example of the negative effect of eutrophication on its economic, recreational and touristic value which makes it an appropriate site for studying lake ecosystem restoration methods and management strategies.
Biomanipulation can counteract eutrophication effects in lakes, whereas nutrient load reductions address their cause. We used an ensemble of two ecosystem-based models to simulate the effects of biomanipulation and nutrient load reductions in Lake Burtnieks: PCLake, a dynamic nutrient turnover model with a simplified food web, and ECOPATH, a detailed mass-balanced representation of the food web. Biomanipulation was simulated by increasing cyprinid harvest and mortality of planktivorous fish (PCLake), or by reducing the biomass of bream (*Abramis brama*), the main cyprinid species in the lake (ECOPATH).
PCLake indicates that cyprinid biomass has to be reduced by 75% and nutrient loads by 30% to achieve good environmental status as defined by the EU Water Framework Directive. According to ECOPATH, low cyprinid fishing and low predation, caused by overfishing of predatory fish, skew the foodweb towards high bream biomass. After reducing bream, zoobenthos biomass is simulated to increase, while zooplankton and phytoplankton are less affected.
The model ensemble supports biomanipulation of the fish community to counteract eutrophication effects in Lake Burtnieks, and suggests a parallel reduction of nutrient inputs.

16. WATER LEVEL CHANGES IN LAKES: ABIOTIC AND BIOTIC EFFECTS

16-O   Effects of submerged macrophytes on water quality through a cycle of water level fluctuations in a lake.   *Jing Lu, Stuart Bunn, Michele Burford*

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Macrophytes play a key role in improving water quality in aquatic ecosystems by assimilating and storing nutrients. However, water level fluctuations (WLF) in lentic systems, due to severe weather conditions or management can change macrophytes from being a nutrient sink to a nutrient source. However, the cycle of nutrient uptake and release rate from submerged macrophytes during WLF has not been well quantified.
Nitrogen release from decayed macrophytes after rewetting can be: 1. released into the water column or adjacent sediments; 2. absorbed by phytoplankton, benthic algae, and other living macrophytes, and 3. de-gassing into the atmosphere by ammonia volatilization and/or denitrification processes. A previous study by the authors identified that decayed and rewetted macrophytes can release significant loads of nitrogen and phosphorus, affecting water quality (Jing Lu et al., submitted).
In this study, a tracer method was used to examine this effect more fully, by directly comparing uptake and release of nitrogen, both in terms of incorporation into plants and release after decomposition of plants, post water level drawdown. Nitrogen-15 (^{15}N) stable isotope incorporation into two submerged macrophytes, the invasive *Cabomba caroliniana* and native *Hydrilla verticillata* in Australia, was measured. Plants were then desiccated and rewetted to trace the fate of ^{15}N after the decomposed plants were rewetted. This involved tracking the ^{15}N signal into the sediment, water column and phytoplankton, and measuring ^{15}N-labelled gas production. The results of this study will be presented providing new insights into the complexity of effects of WLF on macrophytes and ultimately on water quality in lentic systems.

16-O   Effects of water depth on community structure of submerged macrophyte in Xukou Bay of Lake Taihu, a large shallow lake in China.   *Kaining Chen, Shuyun Sun, Wei Huang*

Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, University of Chinese Academy of Sciences, Nanjing, China

The field investigation were carried out to study community structures of submerged macrophyte under the different water depth in April, July, October 2015 in Xukou Bay of Lake Taihu. Meanwhile, sediment and water quality parameters were measured. The results showed that environmental factors such as DO, COD$_{Mn}$, Chl.a and TN were significantly different in different Seasons (P <0.05). We collected a total of 12 kinds of submerged macrophytes, belonging to 7 families. The dominant species was *Potamogeton maackianus*, and the dominance index was 48.6%, 53.9% and 53.2% in spring, summer and autumn, respectively. Correlation analysis showed a significant correlation between depth and diversity, richness and evenness index of submerged macrophyte in summer (P <0.05). As the water depth increased, the diversity, singularity degree and evenness of submerged macrophyte was reduced. The result of CCA analysis showed that the main environmental factors as TN, Chl.a, and depth gradient had effect on submerged plants distribution mainly in summer, there was a positive correlation between depth gradient and the biomass of *Potamogeton maackianus*, and the biomass of *Vallisneria natans* and *Najas marina* were negatively correlated with water depth.

16-O   Sediment memory effects on carbon and nutrient turnover in hydrologically highly dynamic kettle holes?   *Florian Reverey [1] - Hans-Peter Grossart [2] - Katrin Premke [3] - Ganzert Lars [2] - Gunnar Lischeid [1]*

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Kettle holes as a specific group of isolated, small lentic freshwater systems are (i) known as hot spots of biogeochemical cycling and (ii) exposed to frequent sediment desiccation and rewetting. Their ecological functioning is greatly determined by immanent carbon and nutrient transformations. Generally, dry-wet cycles have the potential to increase C and N losses as well as P availability. However, their duration and frequency are important controlling factors regarding direction and intensity of biogeochemical and microbiological responses. To evaluate drought impacts on sediment carbon and nutrient cycling in detail requires the context of the system´s hydrological history. For example, frequent drought events induce physiological adaptation of the exposed microbial communities and thus flatten metabolic responses, whereas rare events provoke unbalanced, strong microbial responses.

To investigate to what extent hydrological history affects the sediment microbial composition and/or activity, sediments from a completely dry kettle hole were taken from three different zones: (i) the deepest point, which has been permanently inundated for more than 3 years and recently fallen dry (Zone A), (ii) the marginal area of the kettle, which frequently dries out and has been dry for 4 months (Zone C) and (iii) an intermediate zone, in which the sediment has desiccated for approximately 2 months (Zone B). Dry sediment samples were incubated at 20°C in the dark and rewetted after 10 days for one month. Sediment carbon, nitrogen and phosphorus species as well as abiotic parameters were monitored before and after rewetting. As a proxy for sediment microbial activity, carbon dioxide and methane production were monitored every 5 days. Sequencing of the sediment bacterial RNA was used to elucidate changes in the active microbial community structure.

We hypothesized a shift of the active sediment microbial community towards that of soils after longer drought events (i.e. Zone B and C). Furthermore, microbial and biogeochemical responses to drying/rewetting were expected to be most pronounced in previously hydrologically stable areas (i.e. Zone A). We assume these memory effects to have significant effects on carbon and nutrient cycling, and thus they should be accounted for when calculating whole system budgets.

16-O   Deterministic ecological flip-flop or stochastic pinball game? ostracod paleoecology in a fluctuating tropical lake.   _Thijs Van der Meeren_, _Dirk Verschuren_

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Lake Naivasha in Kenya's semi-arid Central Rift Valley is one of the few shallow lakes in East Africa with significant importance as freshwater resource. With river inflow from wet headwater areas of its >2300 km^2 catchment contributing a major fraction of its water balance, it is also a classic amplifier lake where relatively modest rainfall variability is translated in significant lake-level fluctuation. The large (currently ca.135 km²) and shallow (max. depth ca. 5m) main basin of Lake Naivasha is connected with the much smaller (1.9 km²) but deeper (max. depth ca. 15 m) basin of Crescent Island Crater. The continuous sediment archive in this crater has allowed studying the evolution of this aquatic ecosystem and its biota over the past 1800 years. During this period, the lake witnessed dramatic shifts between a remnant, small and sometimes saline pond during arid phases, and a highstand freshwater "mega-lake" during relatively moist episodes. These dynamics provided valuable insights into paleohydrology and the paleoclimate history of East Africa, but also the ecological response of diatom, chironomid and cladocera communities to continuously fluctuating habitat conditions.

The Lake Naivasha record also offers the opportunity to study the response of ostracod communities to this eventful environmental history. Ostracods are commonly used as paleo-ecological indicators, but their boom-and-bust population dynamic is often perceived as introducing noise to their potential as paleo-ecological indicators. The reference frame provided by the Naivasha record, with quantitative and independent lake-level and salinity reconstructions (inferences based on sediment lithostratigraphy and diatom assemblages, respectively), allows us to quantify its link with environmental changes, and to test the stochastic nature of the ostracod response.

The fossil ostracod record of Lake Naivasha includes 19 species, most of which have also been found in the living ostracod community of this lake, or in ostracod surveys of Kenyan and Ugandan lakes. These species' ecological preferences and their turnover in the fossil record correspond rather well with the known environmental history of the lake. The assemblage as a whole shows clear response to past fluctuations in lake level and salinity, but also exhibits additional long-term superimposed trends and more 'noisy' characteristics. Variance partitioning indicates that shifts in salinity and lake level explain at best only a modest amount of the total variance in fossil ostracod abundance. Priority effects, which have been shown to partly determine cladocera community composition following lake regressions, appear less important for ostracods. Conversely, the temporal suppression of typical freshwater species in favor of more euryhaline species during saline episodes, and high-frequency abundance variation related to local microhabitat

suitability rather than lake-wide environmental change, may be more important. Overall, this record from a fluctuating tropical lake highlights the complexity of ostracods' ecological dynamics in dynamic shallow lake environments but also underscores the overall deterministic nature of their ecological response in the longer term.

16-P   Does the water level changes influence the fluctuations of *Planktothrix rubescens* (De Candolle ex Gomont) Anagnostidis & Komárek biomass?

Dragana Predojevic [1] - *Ivana Trbojevic* [1] - *Ana Blagojevic* [1] - *Dusan Kostic* [2] - *Sladjana Popovic* [3] - *Gordana Subakov-Simic* [1] - *Prvoslav Marjanovic* [2]*

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Extreme water level fluctuations may result in many negative effects on lake stability and functioning. Some of these are absence of aquatic macrophytes in the littoral zone, changes in nutrient loadings and biotic communities in the lake. Increased biomass and blooming of cyanobacteria could be just the one consequence caused by lowering the water level. The cyanobacterium *Planktothrix rubescens* bloom was detected for the first time in a multipurpose reservoir Vrutci (western Serbia) in December 2013, when the water level was slightly below 615 m a.s.l. (regarding to normal water level of about 621 m), and since then, it has been constantly recorded. Before blooming occurrence, the water level had been fluctuated intensively. After detection of the blooming, water level was maintained relatively stable. The aim of our study was to determine the main factors influencing *P. rubescens* development and to see if the water level is one of them. Samples for phytoplankton and physico-chemical analyses have been collected montly (September – November, 2014 and March – September, 2015) from epilimnion, metalimnion and the hypolimnion at two localities in Vrutci reservoir. During the study period water level varied from 617 to 624,15 m a.s.l. According to phytoplankton analysis, *P. rubescens* was present in all samples, mainly concentrated in the metalimnion (reaching more than 90% of total biomass in some samples). Redundancy analysis was conducted to investigate the relationship between phytoplankton community and physico-chemical parameters with special emphasis on *P. rubescens*. Total phosphorus, that showed a positive correlation with *P. rubescens* biomass, is likely the main factor influencing *P. rubescens* biomass, as well as its percentage within phytoplankton community (regarding to the whole water column). The water level showed an opposite correlation to *P. rubescens* biomass, thus its importance should not be ignored. Water level changes has lower, but still distinct influence on *P. rubescens* development, although analysis was based on small data set (data before blooming do not exist at all), when the fluctuations of water level were lower than usual. Among many other factors, lowering the water level of Vrutci reservoir, especially below normal level, leads to increasing *P. rubescens* biomass and its percentage within total phytoplankton biomass. Further, aquatic macrophytes have been absent in Vrutci reservoir for many years, but maintaining water level relatively stable after blooming led to their regrowth. Specifically, *Polygonum amphibium* L. and *Potamogeton natans* L. emerged for the first time in the litoral zone in June 2015. Questionless, stable water level of any reservoir has a positive effect on biotic community, promoting the presence of aquatic macrophytes and reducing the risk of increased toxic cyanobacteria biomass.

16-P   Changes in the sediment rate before and after the lakeshore development and the appearance of anoxic layer in the epilimnion in Lake Fukami-ke, Japan.

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Changes in depth and decrease of the sediment rate before and after a building breakhead maintenance construction were studied in small monomictic and eutrophic Lake Fukami-ike in central Japan. Lake water stratified from March to October and circulated November to March. Photosynthetic sulfur bacteria accumulated in the hypolimnion in the stagnation period. The maintenance of farm village drainage and the waterfront function was carried out for the activation of the town in 1992, and the water quality improvement was expected. However, variations of transparency were observed and no blue-green algal bloom outbreak had occurred before recently observed. Therefor the changed 30 cm depth from 1992 to 2012 was nearly equal to the calculated data 24 cm depth. (1.2 cm year^{-1} $\times$20 year). Changes in the autochthonous and allochthonous matters in the lake were thus considered. Sediment rates of 19.5 ± 10.19 gm-

$^2d^{-1}$ (1978 to 1979) and 4.40 ± 2.27 gm^{-2}d^{-1} (2007 to 2008) were observed, and decreased 22.6%. These deposition rate data corresponded to 3.1 cm year^{-1} (1979) and 1.2 cmyear^{-1} (2009), respectively. 1.1 cmyear^{-1} (2011) were also obtained in the ^{210}Pb age determination method. The decreased percentage of organic matter and the reduced deposition rate were because rice fields and forest around the lake give way to take concrete roads. It was considered to be because the inflow of sediment stopped when it rained, and allochthonous inorganic matter was significantly reduced. The anoxic layer prevailed throughout the water column from 0 m to maximum depth, which was a very unusual phenomenon in autumn 2013 and 2015. Vertical changes for chlorophyll-a and nutrients were studied and this study reports observations of such appearance of anoxic layer. Therefore, vertical changes for rate of oxygen consumption.

18. UNDERWATER LIGHT CLIMATE: IMPLICATIONS FOR ECOSYSTEM PROCESSES

18-O Light spectrum shifts affect community assembly in perialpine and prealpine lake phytoplankton.   *Maria Stockenreiter, Felicitas Buchberger, Herwig Stibor*

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Lake stratification strengthens with increasing surface water temperatures, thereby reducing the depth of the mixed layer. Stronger nutrient limitation is a widely discussed consequence of such alterations in stratification. However, phytoplankton communities are not only exposed to different nutrient availability within a mixed water column, but also to different light quantity and quality. With decreasing mixing depth, phytoplankton communities are exposed to (integrated) higher light levels and to a broader light spectrum. Longer wavelength (yellow, orange, red) of the photosynthetic active radiation (PAR) are effectively absorbed within the first few meters of a water column and only a reduced light spectrum of mostly blue and green
light penetrates into deeper water layers. As it is very difficult to disentangle the effects of light quantity from light quality in situ, we investigated the response of laboratory and field phytoplankton communities (one perialpine and one prealpine lake) to a gradient of spectral light width quality in controlled laboratory conditions. We analyzed growth, species composition and photosynthetic efficiency of algal communities along a gradient from only blue (430 - 470 nm) to natural white light (PAR spectrum, 400 - 700 nm). Chlorophyta benefited from reduced spectra with increased exposure to blue light, whereas Cyanophyta benefited from exposure to the full PAR spectrum. Our results show that composition, diversity and dynamics of natural phytoplankton communities were strongly influenced by light quality changes. Shifts in spectral light quality therefore leads to altered, and perhaps undesired, phytoplankton community compositions including Cyanophyta as the dominant phytoplankton group.

18-O Ecological consequences of the red-shift of the underwater light climate in shallow lakes.
Boglárka Somogyi [1] - Balázs Németh [1] - Tímea Szabó [1] - Péter Csuti [2] - Ferenc Szabó [2] - Lajos Vörös [1]

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Autotrophic picoplankton (< 3 µm) are of great importance in the carbon cycling and energy flow of oceans and lakes. The colourful coexistence and niche differentiation of phycoerythrin and phycocyanin-rich picocyanobacteria at the blue/green region of the light spectrum is well-known, but the chromatic adaptation of phototrophs along the red end of the spectrum has not been studied so far. On the other hand, the 'red shift' of the underwater light regime, caused mainly by the presence of brown-coloured dissolved substances, is a well-known phenomenon in lakes. The main objective of our study was to describe the influence of the 'red shift' of the light regime on pico-sized algae (picocyanobacteria and picoeukaryotic green algae) by field and laboratory measurements. According to our field measurements, phycocyanin-rich picocyanobacteria had competitive advantage over phycoerythrin-rich ones toward the orange/red region of the light spectrum. With the further 'red shift' of the light climate (deep red light dominance), however, picoeukaryotic green algae prevailed over the other two groups. In order to characterize the light quality preference of isolated picoalgal strains, phycoerythrin-rich picocyanobacteria, phycocyanin-rich picocyanobacteria and picoeukaryotic green algae were grown at nine different wavebands (λ: 430, 460; 505, 525, 600, 610, 630, 660 and 690 nm) under light-limited conditions. As a result, all of the studied groups had different light quality preference. Different light utilization efficiency of the isolates led to their selective advantage at different wavebands: for phycoerythrin-rich picocyanobacteria the green and yellow region; for phycocyanin-rich picocyanobacteria the orange and red region and for picoeukaryotes the blue and the far red region proved to be advantageous. The red-shift of the underwater light spectrum, therefore, results in the success of picoeukaryotic green algae in shallow lakes.The study was sponsored by OTKA PD112449.

18-O   Does light pollution affect benthic primary producers in shallow streams?

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The spread of the electrical artificial lighting worldwide continues to introduce artificial light at night into the environments that have not experienced nighttime illumination before, such as freshwater ecosystems adjacent to urban settlements. Light properties greatly influence photosynthesis and community structure and phenology of primary producers in aquatic systems, therefore changes in light quality, duration, intensity and natural light/dark patterns can potentially have numerous effects on these communities. We simulated night-time irradiance levels comparable with near shore street lighting in outdoor flume simulations to explore how artificial light at night may affect benthic primary producers. We measured biomass and community composition of autotrophs in biofilms at two different colonization stages in two seasons (spring and fall) and evaluated their susceptibility to altered light conditions. Biofilms at early colonization stages responded to nighttime illumination treatment with reduced biomass and increase in diatom content, compared to the biofilms grown under natural dark-light cycles. The responses were highly season-dependent. Contrastingly, pre-established communities were found to be resilient to the illumination treatment. Having in mind the important role of autotrophs in primary production and food webs, we conclude that aquatic systems dominated by biofilms in early colonization stages, such as shallow streams recovering after physical disturbances, may be particularly sensitive to light pollution.

18-O   Relationship between satellite water surface reflectance and in situ estimations of water attenuation coefficient in a large reservoir.

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It is intention of the team to present the relationship between the satellite remote sensing (Moderate Resolution Imaging Spectroradiometer) of spectral surface reflectance and in situ estimation of water column spectral attenuation coefficient. Periodic profiles of spectral downwelling irradiance are performed at Alqueva reservoir, southeast of Portugal, at four sites along the reservoir allowing a reasonable coverage of the surface of the reservoir. A new apparatus, developed by the team, is coupled to a portable spectroradiometer (ASD, Inc.) through a fiber bundle driven by a customized frame for underwater environment and to keep the tip pointing to the zenith direction. The apparatus presents a hemispherical tip (180º of field-of-view) allowing measurements to be independent of solar zenith angle. The profiles obtained throughout the water column can be used to estimate the spectral and broadband light attenuation coefficients. The attenuation coefficients are relevant for the water surface layer energy budget, in particular, this coefficient is important in the computation of the water surface temperature, which is a key parameter for heat and moisture transfers between the reservoirs and the atmosphere, namely by the lake models.

18-P   Does colour matter? Planktivorous fish and zooplankton prey perspectives in different ranges of the visible light spectrum.

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Light is an important factor influencing capabilities of a planktivorous fish as a predator, and is also important to a planktonic animal as an information about the level of predation risk, therefore foraging activity of fish and depth selection behaviour of planktonic animals could be affected by different light spectrum. When estimating capture rates in a typical planktivorous fish (rudd) fed zooplankton prey at three different ranges of the visible-light spectrum, each at two different light intensities, we have found that it was 30% lower in the red than in the green band, and nearly 20%

lower than in the blue band. We hypothesized that the difference in capture rate was due to the difference in reaction distance (the distance from which fish can see its prey to turn into its direction). The hypothesis was verified in an experimental system that allowed the assessment of the reaction distance in each of three ranges of light spectrum. The reaction distance was found to be nearly twice shorter in the red than the green, and 1.5 times shorter than in the blue band in each of the two light intensities for each of the two prey categories of similar body size: 1-day-old *Daphnia longispina* and 2-day-old nauplii of *Artemia salina*, this confirming the hypothesis. Reduction of the reaction distance in red band was accompanied by a decrease in cruising speed, what might be responsible for reduced encounter rate of prey items. The second aim of our study was to test *Daphnia* and *Artemia* ability of assessing differences in mortality risk in accordance to their visual susceptibility within each of the three light spectra. We first determined relationship between light intensity and mortality risk at each of the three bands, basing on the assessed differences in reaction distance and swimming speed of fish feeding on each of the two kinds of prey, using an optimizing, simulating, individual-based model. Then we generated virtual distributions in vertical light intensity gradient at each of the three spectrum ranges. Finally, theoretical distributions were compared with the real distributions obtained experimentally in the same light conditions as those used for simulations. Real distributions were accordant with distributions in simulations, but not for *Artemia*. Obtained results are discussed in the context of natural light conditions in the water column in the field and predation risk for both planktonic animals.

19. PHYTOPLANKTON AND ZOOPLANKTON SPATIAL AND TEMPORAL HETEROGENEITY

19-O   Causes and consequences of parasite epidemics in a *Daphnia* hybrid species complex: the role of cyanobacteria.   *Piet Spaak* [1] - *Christoph Tellenbach* [1] - *Nadine Tardent* [1] - *Barbara Keller* [2] - *Esther Keller* [1] - *Francesco Pomati* [1] - *Ioana Enache* [3] - *Marie-Eve Monchamp* [1] - *Bogdan Druga* [1] - *Justyna Wolinska* [4]

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The annual succession of plankton in temperate lakes is strongly triggered by climatic cues. This succession, however, is a rough framework and the underlying inter- and intra-specific dynamics are still controversial and unforeseen links among different community members might exist. Due to the time and resource-intensive demands for studying such links (i.e. demands of suitably resolved long-term data), insights are progressing only slowly.

Members of the *Daphnia galeata-longispina-cucullata* complex are the dominant herbivorous zooplankton species in larger peri-alpine lakes in Europe. Interspecific hybridization with hybrid dominance (i.e. F_1 hybrids) is a common phenomenon and several factors have been shown to determine the success and succession of *Daphnia* taxa. Studies on lake sediments suggest that Eutrophication plays and important role. When European lakes became eutrophic in the 50ies *D. galeata* invaded the lakes and hybridized with *D. longispina*. Also *D. cucullata* was observed and hybridized with the other two species of the complex. When comparing multiple lakes we could show that *D. longispina* prefers oligotrophic lakes where *D. galeata* is found more in eutrophic lakes, also experimentally these differences could be confirmed.

However, our ongoing 12 year-monitoring study, on zooplankton phytoplankton as well as *Daphnia* genetics in lake Greifensee Switzerland shows that hybrids are not always dominating. One of the reasons for this are parasites. We showed that *D. galeata* and the *D. galeata x longispina* hybrids are infected to a different extend by an Ichthyosporean gut parasite *Caullerya mesnili*. Our genetic studies also show so-called red queen dynamics in the *Daphnia* populations, where rare host genotypes get an advantage as more common clones are higher infected, leading to genotype fluctuations. The host-parasite interactions are further complicated when extending the view to the phytoplankton community: Recently we discovered that there is a relationship between the occurrence of cyanobacteria and *Caullerya* epidemics in Greifensee using time-series analysis. This led to a series of studies in which we investigate the effect of cyanobacteria on *Daphnia* and how they interfere with parasites. Furthermore we used a resurrection ecology approach and laboratory studies to investigate adaptation mechanisms of *Daphnia* to the presence of cyanobacteria.

19-O   Diversity of bacterio- phyto- and zooplankton in perialpine lakes.   *Robert Ptacnik* [1] - *Christian Preiler* [2] - *Blake Matthews* [3] - *Julia Birtel* [3] - *Mia Bengtsson* [4] - *Theresa Lumpi* [2]

Wassercluster Lunz, Aquascale Lab, 3293 Lunz Am See, Austria [1] *- Wassercluster Lunz, Aquascale Lab, Lunz Am See, Austria* [2] *- EAWAG, Aquatic Ecology Department, Dübendorf, Switzerland* [3] *- Institute For Microbiology, University of Greifswald, Greifswald, Germany* [4]

We sampled 60 lakes across Austria, Bavaria and Switzerland, spanning a longitudinal gradient of 800 km. The lakes ranged from 400 and 1400m above sea-level, and spanned from oligo- to eutrophic conditions. We analysed bacterio- and phytoplankton by high throughput sequencing. In addition, Phytoplankton and Zooplankton were analysed microscopically. All groups responde strongly to the trophic state of the lakes. Phytoplankton and zooplankton in addition showed some geographic variation not explained by local environmental conditions, indicating that connectivity among lakes may influence community composition in this fragmented area. In contrast to phyto- and zooplankton, heterotrophic bacteria exhibited a pronounced response to altitude, possibly reflecting a systematic shift in soil and land use with altitude, which in turn affects bacteria through DOM composition. Taxonomic richness was only weakly correlated among groups, indicating that different factors regulate taxonomic diversity in those groups.

19-O   Competition between rotifers (*Brachionus havanaensis* and *Brachionus angularis*) (Rotifera) from the Lake Albufera (Valencia, Spain): influence of mixed diets of alga and cyanobacteria.   *S.S.S. Sarma [1] - S. Nandini [1] - M.R. Miracle [2] - E. Vicente [2]*

Fes Iztacala, National Autonomous University of Mexico, Tlalnepantla, Mexico [1] - Dept. Microbiologia I Ecologia & ICBiBE, Universitat de València, Valencia, Spain [2]

Brachionus havanaensis is predominantly distributed in the Nearctic and Neotropical regions. Later, it was introduced into the Palearctic and Oriental regions. During summer 2015 we found high densities (around 500 ind/L) of this species in the Lake Albufera when the cyanobacterium (*Microcystis aeruginosa*) was dominant in the phytoplankton community. This rotifer is a recent invasor in Albufera, which since 2015 coexisted with *B. angularis*, which was one of the typical summer species in this lake. Because the occurrence of *M. aeruginosa* blooms are also quite recent in this lake, we hypothesized that *B. havanaensis* may be more tolerant to the cyanobacterium. In order to test the hypothesis, we conducted competition experiments between *B. angularis* and *B. havanaensis* from Albufera using the green alga (*Nannochloropis oculata*) and sonicated (single) cells of *M. aeruginosa*, separately and together (1:1 ratio based on biomass). This cyanobacterium was toxic to both rotifers when offered 100% as diet. The competition experiments using the population growth approach showed that *B. havanaensis* had higher population abundances than *B. angularis,* when cultivated separately. However, when in competition with *B. angularis*, *B. havanaensis* showed reduced (nearly 50%) population growth, even in the absence of *Microcystis* in the diet. This reduction of growth was higher than in the treatment of *B. havanaensis* alone when grown on a mixed diet of *Microcystis* and *Nannochloropsis*. The population growth rates of *B. angularis*, alone or in competition with *B. havanaensis*, were similar when *Microcystis* was excluded from the diet. Thus *Microcystis*, even together with *Nannochloropsis*, was highly detrimental for the population growth of *B. angularis*. Our results demonstrate that the competitive outcome between these rotifers depends on the presence or absence of toxic cyanobacteria in the diet.

19-O   Feeding studies on *Diaphanosoma lacustris-mongolianum*: population responses to mixed diets with *Microcystis aeruginosa* and green algae and importance of bacterivory.   *S. Nandini [1] - M.R. Miracle [2] - E. Vicente [2] - S.S.S. Sarma [1]*

Fes Iztacala, National Autonomous University of Mexico, Tlalnepantla, Mexico [1] - Dept. Microbiologia I Ecologia & Icbibe, Universitat De València, Valencia, Spain [2]

Diaphanosoma is one of the genera of cladocerans often coexisting with cyanobacteria in lakes and reservoirs around the world. Here we compared the demographic variables of two clones of *Diaphanosoma lacustris-mongolianum*, from two distinct water bodies (one with a *Microcystis* bloom and the other without), fed with different proportions of *Monoraphidium caribeum* and *Microcystis aeruginosa*, based on life table and population growth studies. We hypothesized that the cladoceran strain naturally co-occurring with *Microcystis aeruginosa* would be better adapted to survive and reproduce on this diet. Our results indicate that both strains showed positive population growth rates in all cyanobacterial diets. There were also significant differences in the response to diets differing in cyanobacterial proportions between the clones obtained from the two distinct water bodies. We cultured the alga *Monaraphidium caribeum* in the laboratory on defined medium while *Microcystis aeruginosa* was collected periodically from La Albufera and sonicated before being used as food (at a final concentration of 0.5×10^6 cells ml^{-1}). We also tested the population growth of the clone from La Albufera on three size fractions of food collected from the same lake; 0-15 μm (seston fraction), 0-3 μm (bacterioplankton) and 3-15 μm (mixed fraction) by filtering lake water through different pore sizes. Our results indicate that both strains showed positive population growth rates on bacterial and cyanobacterial diets ranging from 0.05 to 0.3 d^{-1}. Higher growth rates were observed on the 0-15 μm seston fraction although the cladocerans were also capable of growing well on bacterioplankton alone (<3 μm seston fraction). Growth rates were reduced in the 3-15 μm seston fraction. This indicates the important role of bacterivory by *D. lacustris-mongolianum*. Our results enhance our understanding on the reason why *Diaphanosoma* is common in eutrophic water bodies with a predominance of cyanobacteria, especially *Microcystis.*

19-O   Bloom forming cyanobacteria in Argentina: where do we stand?   *O'Farrell Inés* [1] *- Motta Carolina* [2] *- Marina Forastier* [3] *- Wanda Polla* [4] *- Silvia Otaño* [5] *- Norma Meichtry de Zaburlin* [6] *- Melina Devercelli* [7] *- Ruben Lombardo* [8]

CONICET, Universidad De Buenos Aires, Buenos Aires, Argentina [1] *- Facultad De Ciencias Exactas Y Naturales, Universidad de Buenos Aires, Buenos Aires, Argentina* [2] *- CONICET, Corrientes, Argentina* [3] *- CONICET, Santa Fe, Argentina* [4] *- Aguas de Corrientes, Corrientes, Argentina* [5] *- Universidad Nacional de Misiones, Instituto De Biología Subtropical, Posadas, Argentina* [6] *- CONICET, Universidad del Litoral, Santa Fe, Argentina* [7] *- CONICET, Buenos Aires, Argentina* [8]

Through a meta-analysis of the bloom-forming cyanobacteria, we aimed to synthesise the main reasons that explain the distribution of their blooms in Argentina. We analysed in detail published academic literature, information in technical reports and in non-published studies from 1944 till 2015 in a territory that covers a variety of climates ranging from humic tropical to cold temperate through approximately 3700 km (21°46'S to 66°31'W). Blooms were registered in shallow and deep lakes, rivers, streams, reservoirs, estuaries and storage facilities located along the six lake regions defined for Argentina: Puna, Chaco-Pampa Plain, Peri-Pampean Sierras, Andean Patagonia, Patagonia Plateau and Misiones Plateau. We defined as a quantitative indicator of a bloom a threshold abundance of 5000 cel/ml for a single species in accordance to legislation available in countries located at similar latitudes (Brazil and Australia) as there are no alert levels defined for Argentina. The intensity -maximum registered abundance-, species and ecological strategy responsible of each bloom were related to the geographic and climatologic characteristics of the corresponding location and the type of aquatic system.
We registered and geo-referenced 130 locations related to those aquatic environments affected by cyanobacterial blooms. Puna and the Andean Patagonia regions are free of blooms with the exception of a shallow lake in the latter area. Shallow lakes and reservoirs, appear as the most prone aquatic systems to experience blooms in all regions (44 and 24% of the studied sites, respectively). Deep lakes have no reports ; only at Lake Musters, in the Patagonia Plateau, there is a registered value that is close to the here considered threshold abundance. Rivers are mainly affected at the regulated reaches and the intensity of blooms generally decreases downstream the dams. There were more than 30 different species responsible of the blooms as identified by Komárek's polyphasic approach to taxonomy. *Microcystis aeruginosa*, *Dolichospermum spiroides* and *Cylindrospermopsis raciborskii* were the most frequent, either in mixed or single species blooms. Species distribution differs according the geographic location and the type of aquatic system. While *Microcystis aeruginosa* has a wide geographical distribution through Argentina, *Cylindrospermopsis raciborskii* is mainly circumscribed to the north-eastern territory. On the other hand, the limnological characteristics of the systems are closely related to the eco-strategy of the prevailing bloom-forming species.

19-O   Long-term data reveals linkages between periphytic diatoms and the flood pulse.   *Luciana Carapunarla* [1] *- Pitágoras Piana* [2] *- Liliana Rodrigues* [1]

Universidade Estadual de Maringá, Departamento de Biologia, Maringá, Brazil [1] *- Universidade Estadual do Oeste do Paraná, Centro de Engenharias E Ciências Exatas, Toledo, Brazil* [2]

River-Floodplain systems are characterized by a variety of environments that have the flood pulse as the main feature and as the major structuring effect that keeps these systems in a dynamic equilibrium. Stability can be defined as the structure persistence of a system and/or the tendency it has to remain or to return to a state of equilibrium. Within the concept of stability, it can be defined the resistance stability (ability to withstand disturbance, maintaining the structure intact) and the resilience stability (ability to recover after a disturbance). To better understand these processes in natural systems, studies over an ample temporal scale (long-term) are efficient for checking normal fluctuations, elucidate slow dynamics phenomena, rare events and complex processes. In addition, the use of sessile organisms as biological indicators has advantages, especially due to their response to previous effects of environmental factors. Therefore, this study aimed to examine the stability of epiphytic diatoms along the years 1999 to 2009, in a lentic environment (Patos Lake) of the Upper Paraná River Floodplain. We hypothesized that: a) the stability of the community is dependent on the flood pulse; b) the persistence and the resilience of the species of periphyton diatoms are influenced by the cyclical fluctuations and the seasonality of the floodplain. Along the years studied the water level of the Paraná River was considered irregular, with dry years (no or little flood; ranging from the years 2000 to 2004) and years with intense flood (1999, 2005 to 2009), which reached high levels (high intensity) and lasted long (long duration). The community of periphytic diatoms in Patos Lake was structured according to two significant RDA components of variation. A first component derived from the decomposition of the time series (PCNM 10) identified a recurring pattern of interannual

variability, separating the years of intense flood (higher structure difference in winter) from those with little or no flood (higher structure difference in summer). Years with intense floods favored the development of *Navicula cryptocephala* and *Eunotia minor*, whereas dry years favored *Fragilaria capucina*. The second variation component identified was the water level of the Parana River, which indicated a seasonal variability in the community, separating the highest water sampled in summer, from those lowest water levels sampled in winter. In the summer species such as *Eunotia flexuosa*, *Nitzchia amphibia* and *Ulnaria ulna* were favored the most; in winter favoured species were *Aulacoseira ambigua*, *Gomphonema gracile* and *Cymbella affinis*. Among the 52 identified species, *Aulacoseira ambigua* was characterized as resilient and *Gomphonema parvulum* as resistant. Thus, the hypotheses presented were supported, showing the structuring effect of the flood pulse on the communities of periphytic diatoms.

19-O   Spatial patterns of zooplankton diversity in riverine floodplains.   *Griselda Chaparro, Zsófia Horváth, Robert Ptacnik, Thomas Hein*

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Understanding the spatial distribution of species diversity is a main interest of ecology and its relevance is enhanced under the current scenario of progressive diversity loss. Despite the relevance of spatial scale is increasingly recognized in biodiversity studies, there is still a lack of understanding on how combined environmental variations at smaller and broader scales influence diversity in a certain region. We studied spatial patterns of zooplankton diversity in riverine floodplains from the Upper Danube River in Austria, with the aim to understand how regional diversity is composed and assess the association between beta-diversities and environmental heterogeneity at different spatial scales. We performed a field sampling using a hierarchical multi-scale approach, with particular emphasis on distinct vegetated habitats as hosts of zooplankton diversity. The sampling design included 1- different habitat patches (open waters, submerged, floating-leaved and emergent macrophytes) to account for the variability within water sections and 2- different water sections along a gradient of connectivity with the main river to account for the variability among water sections in the floodplain wetlands. We included three wetlands within the Donau Auen National Park area, where river flooding is still operative and one isolated wetland in an impounded section of the river and compared the patterns among them. We performed the sampling once during summer 2014 after a flood event and once during summer 2015 when no flood occurred. Preliminary results indicate that regional diversity is very high and similar at flooded and non-flooded conditions and that beta-diversity among water sections is the main contributor to zooplankton regional diversity in both hydrological conditions. We are currently exploring the relationship between diversity and environmental heterogeneity at each spatial scale and assessing the influence of local environmental and spatial factors on the composition of these communities.

19-O   Phytoplankton dynamics in a mediterranean varved sediment lake (Montcortès, Southern Pyrenees).   *Pilar Lopez [1] - Joan Goma [1] - Teresa Buchaca [2] - MªCarmen Trapote [1] - Elisabet Safont [1] - Javier Sigro [3] - Nuria Perez-Zanon [3] - Nuria Cañellas-Bolta [4] - Teresa Vegas-Vilarrúbia [1]*

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Lake Montcortès is a Mediterranean lake located in the Pre-Pyrenean range (NE Spain). This lake is one of the few lakes in the Iberian Peninsula that forms biogenic varves, which are able to record past and present changes of environmental signals. This feature makes this lake especially attractive for limnological and paleoclimatic studies in a climatic change context. Some of the concerns are how current climatic change could affect primary producers community, how it could influence the lake's dynamics and which are the forcing factors implied in. This information would help reconstruct climate changes occurred during the last century as inferred from the organism's responses. In order to shed light on this matter a detailed study of vertical and temporal distribution pattern of the phytoplanktonic assemblages and marker pigments composition have been carried out for a two years period (oct-13-oct-15).

Vertical physicochemical profiles were performed and water samples were collected monthly for chemical composition and pigment analyses at the epilimnion, metalimnion and hypolimnion. Phytoplankton samples were collected at the epilimnion and metalimnion and then quantified and determined to species level.

Phytoplankton total biovolume depicted a regular annual cycle with two growth periods, early spring and summer, and a winter minimum. A higher biomass of phytoplankton was observed at the metalimnion, peaking in summer either in biovolume (> $6 \cdot 10^6$ μm^3/ml) or in chlorophyll "a" concentration (> 2 µg/L). Interestingly, chlorophyll "a" showed a decoupling pattern with phytoplankton biovolume. Interannual phytoplankton assemblages showed differences in dominant taxa. While in 2013-2014 central diatoms and chlorophytes followed one another as the dominant taxa, during 2014-2015 small central diatoms took over the entire growing period. These compositional changes matched with the pattern found with the marker pigments revealing a clear seasonal pattern and spatial distribution. The oxygen depletion in hypolimnetic waters during the stratification period allowed a significant development of sulphur bacteria. Studies that join and compare pigments and phytoplankton changes at the species level with environmental variables at a high resolution time control (monthly) and on a detailed depth profile are still sparse. The gathered information will contribute to a better knowledge of the lake's ecosystem responses in an environmental change framework, as well as to build a solid base necessary to carry out accurate paleoenvironmental interpretations by comparing modern and past assemblages (analogical inference).

19-O   Fossil diatom communities of Lake Challa (Kenya/ Tanzania) reveal secrets of recent and historical climate change in East Africa.   _Els Ryken_ [1] - _Christine Cocquyt_ [2] - _Dirk Verschuren_ [1]

Limnology Unit, Ghent University, Ghent, Belgium [1] - _Botanical Garden Meise, Botanical Garden Meise, Meise, Belgium_ [2]

Extreme climate events, such as severe drought and heavy rainfall, frequently affect East Africa and often have a catastrophic impact on the well-being of vulnerable rural populations and their socio-economic systems. Particularly the El Niño Southern Oscillation (ENSO) has a strong influence on the region's weather regime with heavier rains and flooding during El Niño years and intense and prolonged droughts during La Niña years. Based on thin-section analyses of a finely-laminated sediment core from Lake Challa, a crater lake on the border of Kenya and Tanzania near Mount Kilimanjaro, Wolff et al. (2011, _Science_) reported a tight link between the thickness of annual laminations (varves) and inter-annual rainfall variability: thicker varves correspond to drier and windier La Niña conditions, whereas thinner varves correspond to wet El Niño years with less wind. The thickness of the Lake Challa varves is mainly determined by variation in the abundance of diatoms. Windy conditions mix the water column to greater depth and stimulate diatom growth due to the upwelling of nutrient-rich bottom water.

This study concerns a detailed study of changes in the species composition of the diatom communities preserved in these sediment layers over the past 500 years, in order to retrieve more detailed information on changes in the seasonality of rainfall and drought related to the occurrence of climate extremes. We find that in thick varves representing years with dry and windy conditions, the fossil diatom assemblage tends to be dominated by _Afrocymbella barkeri_ (Cocquyt & Ryken), whereas in thin varves representing wetter years with less wind, the assemblage is dominated by a characteristic but as-yet undescribed species of _Nitzschia_. Comparison of our 500-year annually-resolved time series with an independent, decadal-resolution reconstruction of local rainfall based on the organic biomarker proxy BIT (Buckles et al. 2016, _Climate of the Past_) shows that this association of _Afrocymbella_ and _Nitzschia_ dominance with respectively drier and wetter phases also generally holds true for hydroclimate variability with greater amplitude at the (multi-) decadal time scale. Since the mid-1980s a third diatom taxon, _Ulnaria_ sp., has occasionally dominated the dry-season diatom bloom in Lake Challa. It first appeared in 1977, after at least 500 years of absence. Considering that the steep-sided crater catchment of Lake Challa is unaffected by human activity, we envision two possible explanations for the recent appearance of _Ulnaria_. One possibility is that _Ulnaria_ benefits from recently increasing external nutrient supplies, brought to Lake Challa in wind-blown dust mobilized by intensifying agriculture in the wider landscape around Lake Challa. Alternatively, it may have a competitive advantage under conditions of stronger water-column stratification resulting from the recent increase in regional air and surface-water temperature associated with anthropogenic warming.

19-O   Biodiversity and conservation value of saline bomb crater ponds on the Pannonian Plain.

Csaba F Vad [1] - _Robert Ptacnik_ [1] - _Éva Ács_ [2] - _Arnold Móra_ [3] - _Angéla Földi_ [4] - _Zsófia Horváth_ [1]

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Man-made aquatic habitats can fulfil important ecological roles. Ponds formed in world war bomb craters in Europe are typical examples of secondary habitats. On the Pannonian Plain in Central Europe, there are still thousands of such bomb crater ponds, although they are sometimes victims of grassland rehabilitation without a proper evaluation of their biodiversity. To enlighten the value of these habitats for aquatic biodiversity, we studied multiple taxonomic groups (benthic diatoms, zooplankton, macroinvertebrates), focusing on a dense cluster of 54 sodic bomb crater ponds of a confined area (<25 ha). We found that beta diversity dominated over nestedness in all three investigated groups and its species replacement component was always higher than richness difference, which was surprising given the same history and similarity of the habitats. Additionally, the contribution of species replacement to beta diversity was similar among habitats, implying that they are similarly important in maintaining the current gamma diversity. The regional (gamma) diversities of several groups (e.g. diatoms, coleopterans, chironomids) were comparable to other studies covering much wider spatial and temporal scales. When aiming to identify the main drivers of the communities, we found that environmental heterogeneity only accounted for a fraction of variation in the communities, indicating that random effects may also contribute to community assembly. Therefore, we tested how much the spatial structure of the metacommunity contributed to the variation of species composition. In zooplankton, we found a significant fraction of variation explained by unique spatial effects, moreover in rotifers, the unique variation explained by space was similar to that of the environment. This was most likely related to connectivity patters, as the most important spatial eigenvectors indicated the major differences between central and peripheral ponds. In summary, we conclude that despite their anthropogenic origin, bomb crater ponds act as important contributors for aquatic biodiversity. We also found that patterns originating from spatial dynamics can be evident in small-scale metacommunities of zooplankton. These anthropogenic habitats should be carefully taken into consideration in nature conservation, especially considering the serious losses of ponds and other aquatic habitats in the Pannonian Plain and throughout Europe. Besides, they proved to be excellent model systems for community ecology studies.

19-O   Spatial processes due to wind dispersal determine zooplankton metacommunity assembly and gene flow.   *Zsófia Horváth [1] - Haileselasie Tsegazeabe Hadush [2] - Luc De Meester [2] - Csaba Vad [1] - Robert Ptacnik [1]*

Wassercluster Lunz, Lunz Am See, Austria [1] - Laboratory of Aquatic Ecology, Evolution and Conservation, Ku Leuven, Leuven, Belgium [2]

Directional dispersal by wind and other dispersal agents may generate spatial patterns in passively dispersing organisms. We analysed the entire zooplankton (Rotifera, Cladocera, Copepoda) metacommunity and the *Daphnia magna* metapopulation (based on microsatellite data) separately in a cluster of soda pans in a small region of 18 km in Seewinkel, Austria. The area is exposed to a prevailing northwestern wind direction and a perpendicular salinity gradient, providing an ideal study case for an explicit test of the relative roles of local sorting and dispersal on the spatial genetic and community structure of zooplankton. We found strong directionality in the spatial structure of communities corresponding to the wind. Furthermore, the match between community composition and environmental conditions exhibited a spatial pattern consistent with the prevailing wind corridor, with best match found downwind the dominant wind direction. This implied a lessening dispersal limitation gradient. We showed that there is a moderate to high genetic differentiation among the soda pan *Daphnia magna* populations. While no environmental variable proved to be significant driver of the population genetic structure, a significant spatial signal indicated the dominant role of the process of isolation-by-dispersal-limitation, which again corresponded with the wind direction. We found that classical eigenvector methods based on Euclidean distances underestimated the role of spatial processes in our data. Our study furthermore shows that dispersal limitation may constrain population and community assembly in highly mobile organisms even at spatial scales below 5 km.

19-O   Annual changes of the zooplankton community in subalpine Lake Atnsjøen, South Eastern Norway.   *Thomas Correll Jensen*

Norwegian Institute for Nature Research, Research Institute, Oslo, Norway

Despite some recent evidence questioning the traditional assumption that winter is a period of dormancy in temperate and arctic lakes, there is still surprisingly few plankton studies including the winter period. The aim of this study was to examine how the zooplankton community changed during the year, in particular during the long ice-covered period, and how seasonal changes in the environment influenced the community. We conducted an investigation of the

zooplankton community in oligotrophic subalpine Lake Atnsjøen (South Eastern Norway) lasting from June 2010 to October 2011, sampling the lake monthly. In addition to the zooplankton, we also measured important environmental parameters like temperature and food concentration (phytoplankton biomass). The lake was ice covered from the middle of November until the beginning of May. In both years the phytoplankton concentration peaked during the spring bloom in June and leveled off during summer and autumn. The lowest phytoplankton biomass was recorded during early and mid-winter. However, already during late winter a significant phytoplankton biomass had developed under the ice. While the total zooplankton biomass peaked in July both summers, thus tracking the phytoplankton biomass, the total density culminated in August both years, due to high numbers of rotifers. During winter total zooplankton density and biomass remained low, except for a peak in the density of copepod nauplii in April associated with the under ice phytoplankton bloom. Total zooplankton density was most strongly correlated to the water temperature, while total biomass was most strongly correlated to the phytoplankton biomass at the previous census point. Contrary to zooplankton density and biomass, zooplankton species richness remained at the same level during winter as during the growing season, due to a high number of rotifer species. Species diversity (Simpsons index) was high during summer and the beginning of winter, but then decreased during mid and late winter. While Simpsons index and community structure both correlated with the phytoplankton biomass at the previous census point, water temperature only seemed to affect the community structure. The results from spring and summer 2011 illustrate some of the expected effects of climate warming on temperate and arctic ice-covered lakes. As for many other of these lakes the length of the ice-free period in L. Atnsjøen is increasing due to earlier ice-off in spring. In 2011, ice-off was 16 days earlier than the average for the lake (1953-2011). The longer growing season in 2011 as compared to 2010, resulted in a kick-start for the phytoplankton production already under ice in late winter. Furthermore, spring bloom in June and average phytoplankton biomass during the growing season were somewhat higher in 2011. This higher primary production might also be part of the reason for the higher zooplankton density and biomass in 2011 compared to 2010.

19-O   Zooplankton species composition and biomass partitioning in six tropical reservoirs of varying trophic status and retention time.   *Christina Castelo Branco* [1] *- Ewerton Fintelman de Oliveira* [1] *- Adriana L. Puga* [1] *- Vera L.M. Huszar* [2] *- Leonardo C. Souza* [1] *- Priscila Rosa* [1] *- Samira da G. Portugal* [1] *- Maria Isabel de A. Rocha* [1] *- Betina Kozlowsky-Suzuki* [1]

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Planktonic carbon content in tropical reservoirs can be driven by physical, chemical, biological as well as hydrological features of the aquatic ecosystem. Here we show how zooplankton carbon biomass changes seasonally in six different tropical reservoirs (Lajes - RLA, Santa Branca - SBR, Santana - SAN, Vigário - VIG, Ponte Coberta - PCO, IPO - Ilha dos Pombos). In particular, we examined how carbon biomass is partitioned among zooplankton groups. We expected to find a strong effect of rainfall on zooplankton biomass as well as a positive relationship between zooplankton biomass and reservoir retention time. Sampling was conducted in dry and rainy seasons from 2011 to 2014. Reservoirs differed in retention time (RT) (between 0.2 and 300 days), turbidity (3.7 and 60.1NTU), total phosphorus (26 and 152µg.L^{-1}), dissolved inorganic nitrogen (585 and 6,459µg.L^{-1}), and total carbon (3.6 and 10.6mg.L^{-1}). All reservoirs presented low chlorophyll-*a* (between 0.8 and 2.2µg.L^{-1}). Average total zooplankton biomass ranged between 0.29 and 201.4µgC.L^{-1} with the highest value of 802µgC.L^{-1} found in SBR, a mesotrophic reservoir with RT of 30 days. Considering the marked seasonality, there were no statistically significant differences in total zooplankton biomass between rainy and dry seasons. Rotifers dominated in terms of richness having from 32 to 51 species. Some rotifer species contributed constantly to the carbon biomass of the microzooplankters such as *Conochilus dossuarius*, and the invasive *Kellicottia bostoniensis.* Cladocerans contributed with 5 to 14 species, *Ceriodaphnia* spp. were important in terms of biomass in reservoirs with high RT while *Bosmina* and *Bosminopsis* appeared mostly in reservoirs with low RT. Surprisingly *Daphnia gessneri* contributed significantly to the cladoceran biomass in all reservoirs. Calanoid copepods had the highest biomass in all reservoirs, except in IPO the one with the lowest RT, where cyclopoids prevailed instead. Irrespective of seasonality zooplankton biomass was significantly higher in the two reservoirs (RLA and SBR) with highest RT. Although phytoplankton biomass in these reservoirs was similar, zooplankton biomass was much higher in SBR. Despite the highest biomass of potential invertebrate zooplankton predators such as *Chaoborus* and *Mesostoma* in SBR, as chlorophyceans dominated phytoplankton biomass in this reservoir, we suggest that food quality played an important role to zooplankton in this system. Ratio of zooplankton to phytoplankton decreased from mesotrophic reservoirs (average between 2.2 and 9.2) towards both oligotrophic (0.52) and eutrophic reservoirs (0.06-0.74). The biomass of all zooplankton groups correlated positively with chlorophyceans, dinophyceans and zygnemaphyceans in decreasing

order, being stronger in high RT reservoirs. Our study suggests that phytoplankton carbon quality, water transparency and RT can be of great importance influencing zooplankton biomass in tropical reservoirs.

19-O   Male induction between putative cryptic species of *Keratella Cochlearis*.   *Adam Cieplinski* [1] - *Ulrike Obertegger* [1] - *Thomas Weisse* [2]

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In many monogonont rotifers appearance of males is induced by a chemical signal produced by females in response to environmental stress. From an evolutionary point of view, the differentiation in chemical signals may be one of the reproductive (prezygotic) barriers for cryptic species (species that are morphologically indistinguishable).
Many cryptic rotifer species have already been described. Taking into account the morphological similarity of cryptic species, chemical barriers should play an important role in maintaining species boundaries.
Keratella cochlearis (Gosse, 1851) is a ubiquitous freshwater rotifer that shows wide phenotypic diversity and for which potential cryptic species (here termed Evolutionary Significant Units – ESUs) have been discovered, based on the cytochrome c oxidase subunit I (COI).
Using cross-induction chambers, we tested the induction of male appearance between different putative ESUs of K. cochlearis from different alpine lakes. We found that induction between putative ESUs of *K. cochlearis* was possible; however, the threshold of population density as male induction trigger varied between different ESUs. Our results indicate that although reproductive barriers between potential cryptic *Keratella* species are not yet well defined chemically, they may exist.
We also present for the first time, photographs and a detailed description of the males of *K. cochlearis.*

19-O   Freshwater diaptomid copepods of the rocky plateaus in the Western Ghats of Maharashtra, India.   *Mihir Kulkarni, Kalpana Pai*

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Rocky outcrops, which are exposed rock surfaces often devoid of woody vegetation occurring on the tops of mountain ranges or even at lower altitudes. Unique temporary aquatic habitats are often found on such outcrops, and they are globally known to harbour characteristic life forms, despite which they remain an understudied and often neglected habitat. Such outcrops also occur in the Western Ghats of Maharashtra (also known as Northern Western Ghats,NWG), a region largely understudied for its invertebrate diversity. Freshwater diaptomid copepods in temporary habitats on the rocky outcrops of the NWG were studied with the aim of documenting the diversity and studying some aspects of their distribution and ecology in this region.
The outcrops occurring in the NWG were classified as High Level Ferricretes (HLF, >700m), Low Level Ferricretes (LLF, 0-700m) or Basaltic Mesa (BM, 400-1300m) based on published geomorphological data. Qualitative samples (n =285; 49 sites) collected from various temporary habitats formed on different outcrop types in the NWG were examined. Physical, chemical and ecological characteristics of the habitats were noted. Eleven species of diaptomid copepods were recorded in this survey, with representatives of eight genera and two subfamilies. The fauna included Gondwanan, Oriental, Palaearctic and Indian endemic taxa. Among the environmental variables analysed, altitude, mean annual temperature, latitude, electrical conductivity and hydroperiod strongly influenced species distribution. Observed fauna differed across outcrop types, with maximum species observed on HLF outcrops, mostly as characteristic multi-species assemblages. Among habitat types, ponds harboured the most species.
Thirty-two temporary pools and ponds on three HLF plateaus were monitored throughout their innundation cycle (1-9 months) to document spatial and temporal patterns in distribution of diaptomid species. Four species were observed in 27 of these habitats. *Megadiaptomus* sp. was the most common in occurrence and *Paradiaptomus greeni* was the rarest. Most assemblages comprised of 2 or 3 species, where either *Megadiaptomus* sp. or *P.greeni* co-occurred with *Tropodiaptomus orientalis* and/or *Neodiaptomus* sp. The number of diaptomid species observed showed a significant positive correlation to both the depth and area of the habitats. Qualitatively, habitats in close proximity and/or with interconnections showed presence of similar fauna.
Temporary water bodies are globally threatened, and are vanishing rapidly. The rocky outcrops studied face considerable anthropogenic pressure in form of tourism, development, wind-farms and human habitation. There is an

urgent need to study these fragile habitats, and collect baseline data about their biodiversity which can be of immense value to conservation efforts.

19-O   Biodiversity across scales: quantifying inventory plankton diversity by hierarchical measures derived from the Kullback-Leibler divergence.   *Alessandro Ludovisi*

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Intrinsic feature of ecological systems is a high spatial complexity, which results from environmental heterogeneity and interactions among organisms. Therefore, the analysis of the patterns at different spatial/ecological scales constitutes a key step for characterising ecosystem structure, as well as for identifying the underlying mechanisms that determine it. This type of analysis requires dedicated sampling designs and statistical tools capable of extracting information from series of biological data, which are typically multivariate and not continuous. A wide range of indices of diversity and similarity measures is available for quantifying the diversity of natural communities based on abundance data. However, most of the available statistical tools work on single hierarchical levels of biodiversity, not allowing a coherent analysis of the hierarchical structure of biodiversity across spatial/ecological scales. Information theory provides theoretical basis and statistical tools suitable to address this issue. In this contribution, we propose a hierarchical and coherent set of measures derived from the Kullback-Leibler divergence, as a tool for analysing biodiversity at different spatial scales, and present the results of its application in the analysis of plankton spatial data.

19-O   The underestimated role of autumn for zooplankton seasonal resource use and reproduction, as indicated by stable isotope, fatty acid and pigment analyses.   *Milla Rautio* [1] - *Grosbois Guillaume* [1] - *Mariash Heather* [2] - *Schneider Tobias* [1]

Department of Fundamental Sciences, Université du Québec à Chicoutimi, Canada, [1] - *Environment Canada, Government of Canada, Ottawa,* [2]

Autumn has been taken as a quiet season before the dormant winter that in boreal and arctic lakes lasts for three to ten months. Only few studies have been carried out on aquatic ecology during this period when biological activity is reduced, and it is generally accepted that with decreasing photosynthesis other metabolic activity is also slowed down. Many zooplankton populations, however, are abundant in autumn and winter; some even reproduce under the ice. It is therefore likely that carbon sources other than those derived from primary production are available for zooplankton. They, whether autochthonous heterotrophs or allochthonous carbon, should provide enough essential fatty acids for the maintenance of active life and reproduction in winter, or alternatively reserves from autumn phytoplankton feeding should be abundant enough to carry the zooplankton community over the winter months. We addressed the contribution of autumn and winter food sources to the survival, high standing stocks and reproduction of several large-bodied zooplankton in 10 seasonally ice-covered boreal, arctic and alpine lakes. We quantified the pelagic food sources (bacteria, phytoplankton and nanoflagellates), measured bacterial and primary productivity, and sampled organic matter and zooplankton for stable isotopes, fatty acids and pigments. Results show that primary productivity in late autumn allows zooplankton to build a lipid storage that accounts for 40-70 % of the body mass. They also preferably assimilate certain $\omega 3$ fatty acids that seem to have a high role for the winter survival and accumulate carotenoid pigments as antioxidants to prevent oxidative stress in winter. The lipid energy reserve coupled with antioxidant protection allows copepod and cladoceran reproduction in mid to late winter, after months without access to algal food. Stable isotope based mixing models further show that heterotrophic food sources available under the ice contributed only minimally to zooplankton diet in winter and explained only a small portion of zooplankton winter reproduction. Our results show that resource accumulation in autumn is a key to understanding winter ecology, and emphasize that long-term patterns and drivers of ecosystem structure and function may be misunderstood if derived primarily from summer sampling. Critical autumn and under-ice ecological processes may have year-round repercussions on lake productivity, trophic interactions and food availability for higher trophic levels.

19-O   Community composition for associated algae living in the freshwater bryozoan *Pectinatella magnifica* (Leidy, 1851).   *Hyo Gyeom Kim* [1] - *Dong Gyun Hong* [1] - *Seong-Ki Kim* [1] - *Hak Young Lee* [2] - *Gea-jae Joo* [1]

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Biological interactions between different taxa have an important role in sustaining the integrity of aquatic ecosystems. Recently, the freshwater bryozoan (*Pectinatella magnifica*) exhibited a massive spread throughout the 4 major rivers in South Korea due to changes in the aquatic environment. Algae associated with the bryozoan colony were frequently observed in the field, while information about their community composition is limited. We compared species composition of algal communities within a *Pectinatella magnifica* colony and the associated water column to test if algae have any preference for the bryozoan body. We collected bryozoan samples from the Geum River (2 sites) and the Nakdong River (3 sites), S. Korea. *P. magnifica* primarily occurs in summer, thus sampling was performed from June to September in 2014 and 2015. At each site, algae associated with the gelatinous body of *P. magnifica* were collected and fixed with Lugol's solution in the field. Thirty algae-associated *P. magnifica* samples were transported to the lab. To compare algae composition between the external environment and internal environment within *P. magnifica*, the surrounding water sample was collected concurrently. The composition of algae was identified via microscope and the abundance of each species was determined.In total 112 species were identified, with 38 species (33.9 %) being observed in the *P. magnifica*. In the water column, *Cyclotella comta* was the dominant (32.4 %), while *Microcystis* sp. (14.4 %), *Microcystis aeruginosa* (11.2 %), *Aphanizomenon* sp. (6.5 %), *Phormidium valderianum* var. *tenuis* (3.9 %) were subdominant species. In contrast, *Phormidium valderianum* var. *tenuis* was dominant internally to the *P. magnifica* colony, (62.9 %), with *Phormidium tenue* (17.3 %), *Synura uvella* (4.4 %), *Microcystis aeruginosa* (3.4 %), *Phormidium mucicola* (2.7 %) being secondary dominants. Cyanobacteria were the most dominant family within the *P. magnifica* colony for all collected samples. Filament-shaped cyanobacteria (96.2 %) exhibited dominance over spherical cyanobacteria (3.8 %). The relative abundance of algae was higher in the *P. magnifica* (101333.8 ± 24298.7 cells/mL) than in the water column (13265.7 ± 3924.0 cells/mL). Previous studies have also reported the dominance of filamentous cyanobacteria in the *P. magnifica* (i.e. *Oscillatoria limnetica* in USA and *Pseudanabaena* spp. in Czech) colony. Filamentous cyanobacteria possess a physiological adaptation to low light, and therefore can endure the light deficiency occurring in the *P. magnifica* colony. In a while it can reduce mechanical stress from water movement by living in the gelatinous body of *P. magnifica*. Further studies need to focus on establishing a mechanism for the introduction and adaptation of filamentous cyanobacteria into the *P. magnifica* and possible biological interactions between the host and the filamentous cyanobacteria.

19-O   Rotifers (Rotifera) and crustaceans (Crustacea) epizoic on *Dreissena polymorpha* in relation to biotic factors.   *Jolanta Ejsmont-Karabin* [1] - *Maciej Karpowicz* [2]

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Freshwater bivalves (i.e. *Anodonta anatina* (Linnaeus), *A. cygnea* (Linnaeus) and *Unio tumidus* (Philipsson) are known to have an abundant and rich in species rotifer and microcrustacean fauna consisting of rather common species, mostly littoral, but accompanied by pelagic ones. The hypothesis derived from previous studies was that biotic factors may have a strong impact on epizoic rotifer and crustacean fauna of *Dreissena polymorpha*. The mesocosm experiment with water from a eutrophic lake consisted of 4 treatments, three replicates each. The set of treatments consisted of: control (lake water + *Dreissena*), control plus added alien crustacean species, fish and both alien species and fish. Eleven rotifer species occurred exclusively in the epizoon, however only two of them (*Cephalodella eva* and *Lecane pumila*) were noted in more than half of the mesocosms. Not one individual of the species was found in plankton in the experimental mesocosms. The most frequent among rotifers, *Lecane closterocerca,* was noted both in plankton and epizoon but its Index of Habitat Selectivity was 0.26, thus indicating weak preference for epizoic life. Epizoic crustacean fauna of *Dreissena polymorpha* was dominated by littoral species (i.e. *Alona rectangula*, *Alona guttata*, *Acroperus harpae*, *Macrocyclops albidus* and *Nitocrella hibernica*) and it significantly differed from plankton in the experimental mesocosms. Only one species (*Chydorus sphaericus*) was common both in plankton and epizoon.

Relatively high abundance and species richness of epizoic rotifers and microcrustaceans in the experiment, as compared to very low values for epizoon from the same zebra mussels from Lake Boczne, may be explained by a lack of benthic invertebrate predators. In experiment variants with presence of young fish the abundance of epizoon was markedly lower, but higher than in the lake.

19-O   Seasonal changes in carotenoid pigmentation in a freshwater copepod are related to lipid storage and reproduction rather than to photoprotection.   *Tobias Schneider [1] - Milla Rautio [2]*

Group for Interuniversity Research in Limnology and Aquatic Environment (GRIL) & Department of Fundamental Sciences, Université du Québec à Chicoutimi, Canada [1] - Centre for Northern Studies (CEN), Group for Interuniversity Research in Limnology and Aquatic Environment (GRIL) & Department of Fundamental Sciences, Université du Québec à Chicoutimi, Canada [2]

The accumulation of carotenoid pigments in copepods has often been described as a plastic adaptation providing photoprotection against ultraviolet radiation (UVR). However, reports of seasonal carotenoid maxima in winter, when UVR is low, challenge the proposed driving role of UVR. Therefore, we here evaluate the mechanistic connection between UVR and the seasonal pattern of copepod carotenoid pigmentation. We assessed the carotenoids, fatty acid content and reproduction of *Leptodiaptomus minutus* along with UVR exposure, water temperature, phytoplankton pigments, and fish predation in a boreal lake during eighteen months covering two winter seasons. The predominant carotenoid astaxanthin occurred in free form as well as esterified with fatty acids. Mono- and diesters accounted for 62–93% of total astaxanthin and varied seasonally in close correlation with fatty acids. The seasonal variability in total astaxanthin content of the copepods was characterized by a net accumulation rate in late fall of up to 0.034 µg (mg dry mass)$^{-1}$ d^{-1}, which led to the mid-winter maximum of 3.89 ± 0.31 µg mg^{-1}. The two periods of net loss (−0.018 and −0.021 µg mg^{-1} d^{-1}) coincided with peaks of egg production in spring and summer leading to minimum astaxanthin content (0.86 ± 0.03 µg mg^{-1}) in fall. This period was also characterized by the highest predation pressure by young-of-the-year fish. The results suggest that accumulation of astaxanthin in copepods is strongly related to lipid metabolism but not to UVR-photoprotection, and that seasonal changes of fatty acids and carotenoids are related to the reproduction cycle.

19-O   Zooplankton production and allochthony follow different seasonal patterns in a boreal lake.

Guillaume Grosbois [1] - Dominique Vachon [2] - Paul del Giorgio [3] - Milla Rautio [1]

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Zooplankton production is mostly sustained by primary production of phytoplankton and benthic algae, but is occasionally supplemented by allochthonous carbon inputs originating from terrestrial landscapes. Consequently, increasing evidences have demonstrated that zooplankton biomass displays a high share with terrestrial origin (i.e. allochthony) in some lakes. While the mechanisms leading to terrestrial assimilation are complex and still largely unknown, organisms with a high allochthony ratio are mostly aquatic boreal species inhabiting lakes that interact with surrounding forest. Here we studied zooplankton production and allochthony in a boreal lake Simoncouche in Quebec, Canada that is characterized with strong seasonal patterns in carbon availability to zooplankton, including a period of several months of winter when primary production decreases to very low rates but terrestrial organic matter is abundantly available in dissolved and particulate forms. Our main objectives were to 1) identify the temporal variability of zooplankton production that is based on terrestrial carbon assimilation, and to 2) examine how the changes in production relate to aquatic primary production and terrestrial input rates. We hypothesized that, on an annual basis, zooplankton would survive, grow and reproduce using terrestrial inputs as an alternative source when aquatic primary production is too low to sustain their production. To test this hypothesis, we measured the production of the main zooplankton taxa found in the lake (*Leptodiaptomus minutus, Cyclops scutifer, Mesocyclops edax, Daphnia* spp., *Bosmina* spp., *Diaphanosoma* spp, *Holopedium gibberum*) along with primary production and terrestrial inputs for one complete year. Allochthony ratio was calculated from an isotope (^{13}C) algebraic model applied on individual copepod and cladoceran species while zooplankton production based on allochthonous carbon was calculated as the product of zooplankton production and allochthony ratio. Opposite to our hypotheses, even if allochthony ratio was high in winter, the very low zooplankton production under the ice led to a minimum assimilation of terrestrial organic matter. High

terrestrial carbon assimilation in zooplankton took place 1) when total zooplankton production was high, stimulated by elevated temperatures in spring and summer and 2) when terrestrial organic carbon inputs in the lake were the greatest during spring melt and after storms. These results challenge the vision of a maximal use of terrestrial carbon during seasons when organisms show a high allochthony ratio and further suggest that zooplankton production based on aquatic primary production facilitate the terrestrial carbon assimilation.

19-O   Ecosystem stability in interconnected shallow lakes.   *Eyerusalem Goitom, Pieter Lemmens, Laurens Kilsdonk Kilsdonk, Luc De Meester*

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Ecosystem stability and regime shifts gain increasing attention in ecology. The turbid and clear water state of shallow lakes are amongst the best studied examples of such regime shifts, and much is already known about the mechanisms that stabilize the two distinct states. However, most studies on ecosystem stability show either a high temporal resolution or they engage in large scale surveys that are not replicated in time. We here present results from an intensive, weekly monitoring of 25 shallow lakes that are interconnected and part of a large fish pond complex in Flanders, Belgium, during two consecutive years. The study ponds share similar nutrient levels but are yet very different in ecology, ranging from clear-water to turbid systems. In 2014 and 2015, we weekly monitored water transparency, phytoplankton biomass (chlorophyll a and phycocyanin), and macrophyte coverage during the growth season (April-November). Zooplankton biomass and community composition was assessed three times during this period, while macrophyte cover was assessed once. Our results allow a differentiation among lakes that remain clear throughout the growing season, lakes that remain turbid, lakes that shift from the clear-water to the turbid state as the season progresses, and lakes that shift back to the clear-water state after having become turbid. We relate phytoplankton (chlorophyll a) dynamics across the season with zooplankton community composition and macrophyte cover. Our results show that chlorophyll a dynamics are associated with zooplankton community structure during spring and with macrophyte cover during summer. While we observe a correlation in average chlorophyll a concentration and its variation in the ponds across years, we also observe changes in the dynamics of state shifts in the two years for some of the more dynamic ponds. Our data that integrate both seasonal variation as well as variation among ponds and years will allow us to distinguish between regime shift and seasonal shifts that are associated with the onset of fish predation in early summer, and will thus allow a more precise assessment of regime shifts in systems with comparable water quality.

19-O   The response of zooplankton to water level fluctuations in the Cross River floodplain ecosystem, Nigeria.   *Okechukwu Okogwu*

Ebonyi State University, University, Abakaliki, Nigeria

Floodplain lakes primarily help to maintain aquatic diversity, albeit vulnerable to anthropogenic activities. The Cross River floodplain lakes serve as breeding sites to some of the over 166 fish species and several shellfishes of the river. During this study, environmental and zooplankton data collected between 2005 and 2012 from the floodplain lakes were analyzed in order to identify the effect of changes in environmental variables due to water level fluctuations (WLF) on zooplankton biomass and diversity. A total of 132 zooplankton species were identified, comprising 36 cladocerans, 16 copepods and 80 rotifers. The rotifer, *Keratella tropica* and the copepod, *Thermocyclops neglectus* dominated during low water level (LWL) while the cladoceran, *Diaphanosoma excisum* predominated high water level (HWL). Biomass and diversity were significantly lower during LWL compared to HWL. The study also showed that variability in temperature, dissolved oxygen and transparency due to WLF were the dominant structuring factors. The implication of changes in pluvial and anthropogenic activities on zooplankton and fishery diversity is discussed.

19-O   Spatial patterns reveal strong abiotic and biotic drivers of zooplankton community composition in Lake Mývatn, Iceland.   *Mireia Bartrons [1] - Árni Einarsson [2] - Regina L. G. Nobre [3] - Cristina M. Herren [4] - Kyle C. Webert [4] - Sandra Brucet [1] - Sólveig R. Ólafsdóttir [5] - Anthony R. Ives [4]*

University of Vic (UVIC-UCC), Vic, Spain [1] - University of Iceland, University, Reykjavík, Iceland [2] - Universidade Federal do Rio Grande do Norte, University, Natal, Brazil [3] - University of Wisconsin-madison (UW-M), Madison, United States [4] - Marine Research Institute, University, Reykjavík, Iceland [5]

Spatial patterns in the abundance of species are determined by local abiotic and biotic conditions, and by the movement of individuals among localities. For species distributed among discrete habitat ''islands'', such as zooplankton distributed among lakes, local conditions within lakes often dominate low movement rates among lakes to determine the composition of communities. Here, we ask whether the same abiotic and biotic environmental conditions can generate spatial patterns in the distribution of zooplankton within a lake where there are high horizontal movement rates. We conducted three spatial surveys of zooplankton communities in Lake Mývatn, Iceland, a moderately sized (37 km^2) shallow lake with a high outflow rate. The pelagic zooplankton community showed strong spatial structure (spatial autocorrelation), with species composition varying with spatial variation in chlorophyll-a, the abundance of Anabaena (cyanobacteria), lake depth, light extinction coefficient, and temperature. These factors are known from other studies to be strong drivers of among-lake variation in freshwater zooplankton communities. However, in contrast with among-lake studies, fish (stickleback) abundance had no measureable effect on the abundance or species composition of the zooplankton community, although high local stickleback abundance was associated with low zooplankton:phytoplankton biomass ratios. Finally, a parallel study of the underlying benthic crustacean community showed much finer spatial variation (spatial autocorrelation to a range0.6 km vs. 9 km for pelagic zooplankton), suggesting that the stationary character of the benthos allows finer grained spatial patterns. Given the high flow rate of water in Mývatn (.200 m/d), the generation of spatial patterns suggests very strong effects of variation in abiotic and biotic environmental conditions on the population dynamics of zooplankton in the lake.

19-O   Zooplankton size structure and biomass in shallow urban lakes.   *Reliana Lumban Toruan, Elke S. Reichwaldt, Anas Ghadouani*

School of Civil, Environmental and Mining Engineering, University of Western Australia, Crawley, Australia

Urban lakes serve not only as recreational areas for general public, but are also significant habitats encompassing high biodiversity. Urban lakes are typically small and shallow but represent a significant number of waterbodies which have been studied less in comparison with larger, more natural lakes. In addition, being in close proximity to human activities, urban lakes are subjected to a number of anthropogenic stressors, including land use changes, eutrophication and water quality deterioration by which the aquatic environment could be negatively affected. The aim of this study was to examine the spatial and temporal changes in the zooplankton community structure in lakes in relation to urbanisation gradients using organism body size as the primary metric of investigation.

This work represents preliminary results from an ongoing research project examining zooplankton community size and biomass spectra of eight urban lakes in Perth, Australia, in relation to gradients of urbanisation. Zooplankton community size structure samples were analysed by using a high flow-through laser optical plankton counter (LOPC) connected to a lab-circulator which counts particles and quantifies zooplankton size as equivalent spherical diameter (ESD).

Total zooplankton abundance and biomass patterns show spatial variability within and among lakes. Based on average particle count and particle size classes, mean total zooplankton abundance was higher in Lake Joondalup and was dominated by microzooplankton, size between 250 and 375 µm. Total abundance increased as the number of microzooplankton counts increased, but has the least contribution toward total biomass. Biomass aggregate (mg L^{-1} wet weight) at all waterbodies was attributed to larger zooplankton, sized between 750 to 2500 µm, and it is particularly noticeable for lake Yangebup where the overall zooplankton biomass is controlled by zooplankton size greater than 1000 µm regardless their lowest proportion to total density (ind L^{-1}). The contribution of microzooplankton to the overall biomass was significantly low in the presence of largest sized zooplankton and increased as this size groups absence from the systems. Initial analysis showed no correlation between main environmental parameters and composition of zooplankton size fraction or biomass distribution, which could be due to the small range in the environmental parameters.

Further analyses will include land use, waterbody size, cyanobacteria biomass and water management practices together with the increase in both temporal and spatial sampling frequency to better understand the driving factors of zooplankton communities in urban lakes.

19-O   Effects of the type ii diabetes treatment drug (metformin) on the demographic variables of *Moina macrocopa* (Cladocera) .   *Gerardo García García* [1] *- S.S.S. Sarma* [1] *- S. Nandini* [1]

Fes Iztacala, National Autonomous University of Mexico, Tlalnepantla, Mexico [1]

During the last few years, the presence of pharmaceuticals in freshwater bodies and tap waters has received considerable attention because xenobiotics including drugs had a hormone mimicking the effect on non-target organisms, at concentrations as low as nanograms per liter. Hence, we need more information on the effects of widely used drugs on aquatic organisms. Globally type II diabetes is one of the biggest chronic health issues and for treating this, metformin is widely used. Because of lack of a rigorous control, some of the drugs including metformin reach waterbodies as effluents. In order to understand the effect of metformin on the zooplankton species, we exposed *M. macrocopa* to metformin hydrochloride at three concentrations (25, 50 and 100 µg L^{-1}). This range was based in field measurements of metformin levels in effluents. We also compared the demographic responses of *M. macrocopa* using analytical grade metformin and commercially available tablets. Regular cohort life table experiments were conducted at 25 ±1 °C using *Scenedesmus acutus* at 0.5x10^6 cells mL^{-1} as diet for the cladocerans. The test medium with the same conditions (algal density and metformin concentration) was renewed every 24 hours. We derived selected life history variables (fecundity, survivorship, average life span, gross rate reproduction, net rate reproduction, generation time and the rate of population increase per day). Our results showed that metformin had an adverse effect on both the survival and reproduction-related variables. In addition, an increase in the level of metformin had an adverse impact on the reproductive rates of *M. macrocopa*. There was a close similarity on the adverse effects of technical and commercial grade metformin to the tested zooplankton species. Our results further suggest that governmental regulatory laws are needed for the safe disposal of most widely used drugs.

19-P   Characterisation of microscale phytoplankton variations in various aquatic environments using high resolution sampling.   *Kerstin Häggqvist, Tore Lindholm*

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Phytoplankton micro patches last enough time for competition, predation, or infections to take place. Consequently, processes at the microscale inevitably have implications at the large scale. Still, studies of processes within phytoplankton communities and how they structure the communities are scarce. An important part of phytoplankton community ecology may therefore be revealed by studies at the microscale. Results obtained with conventional sampling, i.e. integrated samples of one litre, do not necessarily correspond to scales relevant for individual phytoplankton species. That is, the spatial variability in aquatic environments is often a result of processes at scales that are smaller than those studied. As organisms interact with their immediate surroundings an ecologically relevant scale for phytoplankton is the micro- to centimetre scale. Appropriate results of processes at the microscale can only be obtained with a proper sampling method. We studied microscale variations with a high precision sampler, built from off-the-shelf low-cost parts; a polyethylene hose, a weight and a float. By modifying the sampler, vertical microscale studies of phytoplankton were done in the reed belt, among submerged macrophytes of two different morphotypes (*Vaucheria* and *Myriophyllum*), under the ice and in rock pools. Minute variations in phytoplankton distributions, as well as in physical and chemical variables, were revealed in all the studied environments. The applied high resolution sampling enabled characterisation of the microspatial distribution of individual phytoplankton species. Microscale studies of individual phytoplankton species in relation to environmental conditions might increase the knowledge of their functional traits and ultimately of internal processes shaping the phytoplankton communities. As communities are not isolated and they function across scales, studies of species distributions at various scales in different environments are important.

19-P   Copepods act as omnivores in an oligo-mesotrophic reservoir: implication for the top-down control on phytoplankton.   *Qiuqi Lin, Bo-Ping Han*

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Reservoirs receive large amount of organic matter from surrounding watersheds, representing a significant resource for zooplankton consumers. Whether copepods tend to be omnivorous in such heavily subsidized system and their potential cascading effect on phytoplankton are debated. We examined the seasonal dynamics of zooplankton and Chl:TP ratio over a one-year period, and used stable carbon and nitrogen isotope analyses to elucidate the feeding habits of three dominant zooplankton species (*Diaphanosoma orghidani*, *Phyllodiaptomus tunguidus* and *Mesocyclops thermocyclopoides*) in an oligo-mesotrophic reservoir. The $\delta^{13}C$ of bulk POM was less ^{13}C-depleted in the flood season (mean=-26.4±1.4‰) than in the dry season (mean=-30.0±0.2‰), and increased with inflow. Zooplankton $\delta^{13}C$ were positively related to the $\delta^{13}C$ of POM, indicating seasonal change in the extent of zooplankton allochthony. Both calanoids and cyclopoids showed varying degrees of omnivory, with difference of ca. 1.0-3.3‰ between *P. tunguidus* and filter feeder *D. orghidani* $\delta^{15}N$ and -0.8-3.7‰ between *M. thermocyclopoides* and *D. orghidani* $\delta^{15}N$. Zooplankton biomass was positively related to Chla and $\delta^{13}C_{POM}$, and displayed two peaks: a major one primarily contributed by *D. orghidani* in the early flood season and a minor one primarily contributed by *P. tunguidus* in the early dry season. Chl:TP ratio was much higher in the dry season (mean=0.30±0.05) than in the flood season (mean=0.19±0.06), and was negatively related to Cladoceran:Phytoplankton biomass ratio and Cladocerans:Omnivorous copepods biomass ratio. Our results suggested that copepods tend to be omnivorous which may weaken the top-down control of zooplankton on phytoplankton and increase the TP to Chlorophyll transfer efficiency.

19-P   Diversity and spatial distribution of ostracods in the surface sediments of Lake Constance, Germany: potential use as groundwater influx indicators?

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Lake Constance is the second largest lake in Central Europe with a catchment area of 11,500 km^2, a mean depth of 90 m and surface of 536 km^2. It has high ecological, social and economic value, and belongs to the largest and one of the most important drinking water reservoirs in Europe, supplying water for around 5 Million people. It has undergone a process of eutrophication until the late 90's, which triggered several impacts, including loss of biodiversity. Nowadays the lake is oligotrophic but recently, structures at the bottom were found that may indicate groundwater inflows into the lake. In order to identify biological indicators of these inflows and to assess their effect on biological communities and water quality we use the diversity and spatial distribution of ostracods. Thirty-two surface sediment samples were taken in June 2015 using a van Veen grab in water depths ranging between 10 and 115 meters. We identified fifteen ostracods taxa belonging to 6 families and 13 genera (*Candona*, *Fabaeformiscandona*, *Pseudocandona*, *Leucocythere*, *Limnocythere*, *Limnocytherina*, *Cytherissa*, *Potamocypris*, *Herpetocypris*, *Isocypris*, *Prionocypris*, *Darwinula* and *Ilyocypris*) were identified. Limnocytheridae was the most abundant group. *Limnocytherina sanctipatricii* was the most abundant species with a relative abundance of 36%, followed by *Leucocythere mirabilis* (34%) and *Limnocythere inopinata* (24%). The spatial distribution of ostracods was assessed by principal component analysis (PCA) and 3 groups were identified, showing a longitudinal distribution. The association of *L. sanctipatricii* with deep sites is confirmed, while *L. mirabilis*, usually recorded as deep cold water species, was the most abundant species in shallow sites (5,7 m). Potential groundwater inflow indicators, such as *Prionocypris zenkeri* and *Darwinula stevensonii*, were found in sites with suggested groundwater inflows, but their abundances are low (6% and 1%, respectively). Further investigation in combination with other tracers is being performed. This study is part of the "ReWaM Joint Project - Using tracers to identify groundwater and surface water input to lakes and the importance for water quantity and quality: Case study from Lake Constance (SEEZEICHEN)" supported by the German Federal Ministry of Education and Research (BMBF).

19-P   Heterogeneity in prey distribution allows for higher food intake in planktivorous fish, particularly when hot.

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When prey are scarce, planktivorous fish and other predators feeding on tiny prey should forage within prey-rich patches to attain a net food intake above the ambient mean food concentrations. If they can indeed locate prey-rich patches efficiently, then a patchy distribution of planktonic prey should lead to: 1 an increase in the overall per-capita

food intake and 2 greater variability among predators in prey capture rate due to differences in arrival times. Both phenomena were observed in 34 daily feeding sessions with a cohort of juvenile rudd held in twin experimental systems, each housing the same number of fish free to move in a loop of 10 interconnected 200L tanks. The fish were fed daily with equal numbers of planktonic prey (*Artemia* naupli)*,* offered either in a homogeneous or patchy distribution. To simulate low and high temperatures that represent potential global warming scenarios, the feeding protocol was replicated at 16, 21 and 26°C, on each occasion following a 3-day period of fish acclimation. Up to 40–70% of fish in the system with the patchy prey distribution assembled rapidly in the high-prey-density tank, the capture rate of first arrivals being up to 60 prey min^{-1} in 26°C, orders-of-magnitude greater than that of latecomers. The overall capture rates were higher in the system with patchy prey, regardless of the temperature. At the highest temperature (26°C), the fish located the high-prey-density tank in less than half the time taken at the lowest temperature (16°C, $Q_{10} > 2$).

19-P   Zooplankton structure and physicochemistry of two dissolutions lakes (sinkholes) in the Yucatan Peninsula, Mexico.   *Adrián Cervantes-Martínez* [1] - *Martha A. Gutiérrez-Aguirre* [1] - *Victor H. Delgado-Blas* [2]

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The planktonic communities composed of rotifers and microcrustaceans of two tropical karstic lakes in the Yucatan Peninsula, Mexico, with similar origin but different trophic state were analyzed. Both systems, the meso-eutrophic (El Padre) and oligotrophic (Minicenote) were considered as monomictic lakes. The abundance, temporal distribution of species, richness, diversity and body size were measured and discussed in relation to the influence of abiotic factors and the presence of a natural predator. These analyses indicated that these tropical systems were not homogenous for several of these measures at both spatial scales and during the annual cycle analyzed, despite their reduced temperature variation compared to temperate lakes. The results indicated that the dynamics in the zooplankton community were related to the environmental factors, the opportunistic species (with maximum densities related to resource maxima), and the exploitative competition between the dominant herbivorous species. Independently of the trophic condition, the abundance, richness, and diversity were lower during the mixing period. During the annual cycle studied in the meso-eutrophic system, the key environmental parameters related to plankton abundance were pH and temperature whereas in the oligotrophic system, oxygen concentration was important. In both lakes, richness and diversity were related to conductivity, although in the oligotrophic lake the relation was negative whereas in the meso-eutrophic lake it was positive. we also found differences in the sizes, both, no relationship was found between the abundance of the studied predator (*Chaoborus* sp.) and the changes in the body size, abundance, diversity and richness of zooplankton in the systems.

19-P   Ichness of the genus *Mastigodiaptomus* (Light, 1939) in Mexico.   *Martha A. Gutiérrez-Aguirre, Adrián Cervantes-Martínez*

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Mastigodiaptomus (Copepoda: Calanoida: Diaptomidae) is a freshwater, Neotropical calanoid genus with high richness in the Americas. The genus is distributed from the southern region of the USA to Guatemala and Cuba. In Mexico are distributed eight of the ten known species of the genus. This study provides information about the richness of the genus in Mexico considering genetic results based on barcodes, morphology based on scanning electron microscopy images, and morphometric analyses based on multidimensional statistics. In addition, a full description of adult females and males of a new species assignable to the genus *Mastigodiaptomus* (*M. cuneum* sp. nov.) is presented here. The specimens of the new species were collected in one endorheic freshwater system, on the Nearctic region, in the Sonora Province. These findings add to recent reports of the presence of cryptic species, morphologically similar to *M. albuquerquensis* in Mexico. The morphological analyses coincided with the genetic markers and these analyses allow to define that the new species is genetically closer to *M. montezumae* (Brehm, 1955), which is distributed on the Mexican Plateau. The genetic difference within the analyzed species was higher than 5%. Morphologically, the ornamentation of the basis of the right male fifth leg, the right exopodite, and the right antennule in males; or the ornamentation of the prosomal wings and the lateral margins of genital-double somite in females are very informative for species recognition

of the genus *Mastigodiaptomus.* This study contributes in establishing real patterns of species distribution and genetic acquisition from megadiverse hotspots such as Mexico.

19-P   Metacommunity dynamics of Ostracoda in temporary lakes: overall strong niche effects except at the onset of the flooding period.   *Andreu Castillo-Escrivà, Luis Valls, Carlos Rochera, Antonio Camacho, Francesc Mesquita-Joanes*

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Metacommunity research usually focuses on the structure of species assemblages and their influencing factors, chiefly environment and space. However, the temporal dynamics of metacommunities and their structuring processes are rarely investigated. Here, we analyze the temporal variations in a metacommunity of ostracods from temporary shallow lakes of the Iberian Peninsula. Our aims were to determine the variability of the ostracod assemblages throughout a hydrological cycle by means of partial triadic analysis (PTA), and to analyze the response of these communities to both environmental and spatial variables. The metacommunity was moderately stable through the study frame period, with larger variability between sites than between months. However, the metacommunity structure at the beginning of the hydroperiod was notably different from the rest of months. Species sorting was the predominant mechanism structuring the metacommunity through monthly samples, establishing a conspicuous separation between species that inhabit saline lakes and those preferring freshwater bodies. Spatial processes were negligible. Our results show the strength of a temporal approach in the study of metacommunities, against a single snapshot, stressing differences at the onset and the end of hydroperiod in temporary water bodies, but still surpassed by species sorting effects under a steep environmental gradient. This work was supported by the project *ECOLAKE* (CGL2012-38909).

19-P   Zooplankton from karstic lakes in Central Spain: vertical distribution and relationship with environmental factors.   *Xavier Armengol, Luis Valls, Andreu Castillo*

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Zooplankton communities from several lakes and pools in three zones of a karstic area in central Spain were studied in early autumn, when lakes still remain stratified. The most abundant species, in the whole water column, were the rotifers (in decreasing abundance): *Anuraeopsis fissa > Hexarthra mira > Polyarthra dolichoptera > Keratella quadrata > Trichocerca similis > Synchaeta pectinata*; and the crustaceans: *Tropocyclops prasinus > Diaphanosoma brachyurum > Daphnia longispina > Ceriodaphnia rectangular > Cyclops abysorum*, The vertical distribution of the most abundant species is shown as well as the relationship of zooplankton communities with some environmental and spatial variables, in the frame of metacommunity analysis.

19-P   Seasonal variations of sessile rotifers (Rotifera: Gnesiotrocha) on the macrophyte *Eicchornia crassipes* from Lake Xochimilco, Mexico.   *Marco Antonio Jimenez* [1] - *S.S.S. Sarma* [2] - *S. Nandini* [2]

Posgrado en Ciencias del Mar y Limnologia, National Autonomous University of Mexico, Mexico, Mexico [1] - *Fes Iztacala, National Autonomous University of Mexico, Mexico, Mexico* [2]

Sessile rotifers are common in the littoral region of most water bodies and in shallow lakes, often attached to macrophytes. Little information is available on these organisms and one of the reasons for this is that they need to be identified in when alive; adequate fixing reagents are not yet available for these organisms. Hence the paucity of information on these rotifers as compared to planktonic taxa. In this study we present information on the seasonal variations of sessile rotifers from Lake Xochimilco in Mexico City. We collected samples of zooplankton during 2015-2016 period from the roots of the macrophyte *Eichhornia crassipes*, identified and quantified the sessile rotifers. Simultaneously we also evaluated selected physical and chemical variables such as dissolved oxygen, temperature, pH, conductivity, hardness and the concentrations of nitrates and phosphates. In all we were able to determine 17 sessile rotifers belonging to the genera *Beauchampia, Collotheca, Flosacularia, Ptygura* and *Stephanoceros*. The dissolved oxygen ranged between 2.4-14.3 mg L^{-1}, temperature from 13.8-23.5 ºC, pH from 6.7-8.0, conductivity from 672-874

mS/cm, hardness 148-184 mg L^{-1}, nitrates from1.5-4.4 mg L^{-1} and phosphates from 0.7-4.8 mg L^{-1}. The most common species during the study period were: *Collotheca campanulata*, *Limnias ceratophylli* and *Stephanoceros millsii*. The maximal densities of the sessile rotifers were in the range of 50-100 ind./g root wet weight. Physico-chemical and biological data were analyzed using the CANOCO multivariate analysis statistical program.

19-P   Effects of cyanobacteria crude extracts on the demography of *Brachionus calyciflorus* (Rotifera).   Cesar Alejandro Zamora Barrios [1] - S. Nandini [2] - S.S.S. Sarma [2]

Posgrado en Ciencias del Mar y Limnologia, National Autonomous University of Mexico, Mexico, Mexico [1] - Fes Iztacala, National Autonomous University of Mexico, Tlalnepantla, Mexico [2]

Cyanotoxins from cyanobacterial blooms in lakes or eutrophic reservoirs are toxic for many members of the zooplankton community. There are few studies on the effect of cyanobacterial crude extracts on zooplankton in tropical countries. In this study information on the effect of crude extracts from a cyanobacterial bloom consisting of *Microcystis* spp. from an urban lake, Chapultepec (Mexico City) is presented. The cyanotoxins were extracted by freezing at -70° C and thawing five times; between each cycle cyanobacteria lysis was carried out using a sonicator. Once the extract of *Microcystis* was obtained acute and chronic toxicity tests were conducted. The experiments of LC$_{50}$ (24 hours) on *Brachionus calyciflorus* (2, 4, 6, 8, 10, 12 and 14% of crude extract diluted in EPA medium) showed that 50% of the population died around of 10.48% dilution of the crude extract. Based on these results we calculated sub-lethal concentrations for the demographic studies. Population growth and life table experiments were conducted using two chronic concentrations (1 and 5% of crude extract) at three different temperatures (20, 25 and 30°C). The results are discussed with emphasis on the importance of conducting regular studies to test the ecotoxicological impacts of cyanobacterial blooms in tropical waters.

19-P   Feeding preferences of *Stenostomum* spp. (Turbellaria: Catenulida) in the littoral-benthic area of Benito Juarez Reservoir, Villa del Carbon, Mexico State.   Alma Rosa Núñez-Ortiz [1] - S. Nandini [2] - S.S.S. Sarma [2]

Posgrado en Ciencias Biológicas, National Autonomous University of Mexico, Mexico, Mexico [1] - Fes Iztacala, National Autonomous University of Mexico, Tlalnepantla, Mexico [2]

Zooplankton in lakes and reservoirs often migrate horizontally thus reaching the littoral zones of these water bodies. This facilitates a greater interaction between planktonic and benthic organisms. Freshwater flatworms, commonly associated to benthos and macrophytes, can exert a pressure on their prey, including planktonic organisms, particularly ciliates and rotifers. Many flatworms reproduce asexually reaching high densities in the shallow regions of freshwater systems. The turbellarian genus *Stenostomum* is one of the most common and abundant in the littoral regions of lentic and lotic water bodies in Mexico. In this survey we examine the feeding preferences of *Stenostomum* spp. in the littoral zone of the Benito Juarez Reservoir associated with the macrophyte *Egeria densa*. We collected samples once a month, for six months and analyzed the stomach contents of 10-20 live *Stenostomum*. After that we enumerated the zooplankton from the samples using a Sedgewick Rafter cell. Based on the data obtained we calculated the prey preference index using Manly's alpha. We found that most individuals of *Stenostomum* had a preference for the rotifer *Trichocerca porcellus* and diatoms. Often the guts were filled with unidentifiable organic matter. Observations from other water bodies in Mexico also indicate that these organisms feed on several littoral rotifers such as *Lepadella*, *Testudinella* and bdelloids. Our results suggest turbellarians could play an important role in structuring littoral rotifer communities.

19-P   Seasonal variations of crustacean zooplankton from a high altitude water body (Llano dam, State of Mexico) in central Mexico.   Manuel Eduardo Muñoz-Colmenares [1] - S.S.S. Sarma [2] - S. Nandini [2]

Posgrado en Ciencias del Mar y Limnologia, National Autonomous University of Mexico, Mexico, Mexico [1] - Fes Iztacala, National Autonomous University of Mexico, Tlalnepantla, Mexico [2]

There are few studies on zooplankton from high altitude waterbodies of tropical countries. Although central Mexico has many high altitude waterbodies, knowledge on the seasonal variations of crustacean zooplankton is limited. In this work we present data on the seasonal variations of cladocerans and copepods from a high altitude waterbody, Llano Dam, State of Mexico, located at an altitude of 2600 m above sea level, during one year (2014-2015). The zooplankton samples were collected monthly at five stations using 50 micro meter (pore size) plankton net. Simultaneously, we also measured selected physico-chemical variables (dissolved oxygen, temperature, pH, conductivity, turbidity, nitrate and phosphate levels). Zooplankton samples were collected by filtering 80 L of lake water and fixed in 4% formaldehyde. The crustacean species were identified, as far as possible, to the species level. The mean values of physico-chemical variables of the water body were, dissolved oxygen: 7.7 mg/L, temperature: 15°C, pH: 6.4, conductivity: 69 µs/cm and turbidity: 2.4 NTU. We were able to identify 13 species of cladocerans and 2 genera of copepods. The family Chydoridae had the highest number of species 8. The most abundant crustaceans were copepod nauplii (up to 455 ind./L), copepodites (47 ind/L) and *Chydorus brevilabris* (77 ind./L). The rest of rest of the crustacean species were in low abundance (<10 ind./L) during most part of the year. A canonical correlation analysis was run to explain the effect of physico-chemical variables on the seasonal variations of the crustacean species.

19-P   Information technology services revolutionize phytoplankton counting.   *Kalevi Salonen* [1] - *Tomi Lundberg* [2] - *Pauliina Salmi* [3] - *Ville Tirronen* [2]

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A great deal of attention has been paid to quality assurance of phytoplankton counting, but quality control has been almost totally neglected. While there are a few computer programs available for counting, the potential services of information technology have hardly been realized. Assuming that phytoplankton are randomly distributed on preparations for counting, in 1950s Lund et al. suggested a shortcut method for the estimation of the confidence limits of the results. Although it is still recommended in many standards, its use has been limited and retrospective. Further, its assumption has been demonstrated to be generally invalid for field material. To introduce quality control as a routine in phytoplankton counting and to improve the whole counting process we designed a simple counting environment which materializes the advantages of the combination of statistics and information technology services.

Our phytoplankton counting environment is implemented in the Internet as an open-access program which applies a wide repertoire of features related to counting. These streamline and motivate the counting process and consequently greatly enhance usability. For the first time confidence limits are available in real-time during counting, thus providing an objective basis for the selection of a proper counting strategy and allow the standard confidence limits of the results. In contrast to present standards, each species in a sample may be counted in its optimum way according to its own counting statistics and the research objective at the time. We call this dynamic counting. It provides a universal means to count phytoplankton under a simple, but single, layout. We believe that our approach paves the way for a future counting standard where the quality of the results rather than the number of counted cells dictates how samples are counted.

Due to the huge size spectrum of phytoplankton, the estimation of the confidence limits of biomass is even more challenging than the counting of numbers, but has received no attention in standards of practical counting. The major problem is that a few large species may dominate calculations of total phytoplankton biomass, but their generally low abundance renders confidence limits poor. Our program characterizes the relative contributions of different species (or size classes) to the total biomass so that one can readily infer the most economical allocation of one's work effort.

Digital photography is integrated in the counting environment so that later tracing of species identification is straightforward. Proper identification is also supported by readily available drawings and dimensions of species to be counted as well as by previously archived photos. Our counting environment ushers counting throughout the process so that neither quality nor efficiency is compromised. We believe that it is one of the most important advances in time consuming phytoplankton counting since the time of the early pioneers in 1950s.

19-P   Phytoplankton and zooplankton in four adjacent shallow lakes with different trophic state.

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Eastern Quarry, located in the southern part of Mexico City, Mexico, has four small and shallow lakes (North, Central, South and Regulation Lakes) filled by spring water. It is part of the Ecological Reserve of San Angel Pedregal, an urban ecological protected area. In 2015, compared annual limnological study was conducted on these water bodies that show clear trophic differences. Spring water contains high quantities of inorganic compounds of nitrogen and phosphorus due to groundwater pollution and it seems to be the main source of nutrients to the lakes. Trophic variables indicated that North and Central lakes are eutrophic. Secchi disc values were medium to high (0.25-1.2 m), pH range 6.7-9.3 and chlorophyll *a* varied between 7 to 278 µg L^{-1}. Total nitrogen (Tot-N) and phosphorus (Tot-P) were 4.3-7.9 mg L^{-1} N, and 0.12-1.05 mg L^{-1} P. South lake was hypertrophic with low Secchi disc (0.18-0.5 m), pH between 8.8 and 9.8 and the highest chlorophyll *a* concentrations (88-622 µg L^{-1}). Tot-P was 0.12-1.05 mg L^{-1} P and Tot-N 6.8-8.6 mg L^{-1} N. Regulation lake varied between mesotrophic to eutrophic with high values of Secchi disc (1.0-1.4 m) and lower of pH (7.2-9.0) and chlorophyll *a* (4-56 µg L^{-1}). Tot-P values were low (0.11-0.35 mg L^{-1}) but Tot-N was higher (6.8-8.6 mg L^{-1}) due to the spring water content of nitrate. In North and Central lakes phytoplankton species composition was similar and dominant species were mainly chlorophytes such as *Desmodemus maximus*, *D. opoliensis* and the cryptophyte *Cryptomonas ovata.* In the cold season *Chlamydomonas reinnhardtii* and the diatom *Cyclotella menenghiniana* showed high densities. Dominance in the South lake included the cyanobacteria *Microcystis aeruginosa* and *Pseudanabaena* sp., and the chlorophyte *Pseudopediastrum boryanum*.   Regulation lake shares many dominant species with the other three but densities were much lower. Overall zooplankton composition and abundance was dominated by rotifers, but there were also differences between lakes. In North, Center and South lakes the genus *Keratella* and *Brachionus*, typical of eutrophic conditions, were dominant. *Keratella cochlearis* was a dominant species in all lakes. In the North and Central lakes *Brachionus angularis* and *B. quadricauda* were abundant while in South lake *B. caudatus*, *K. americana* and *Trichocerca pusilla* were important. *Bosmina longirostris*, a small size cladoceran, was present in all lakes but it was dominant in North, Central and Regulation lakes, and scarce in South lake. It was also relevant the temporal presence of *Daphnia ambigua* in North, Central and Regulation lakes but not in the South lake. We conclude that lakes of Eastern Quarry show differences in their phytoplankton and zooplankton composition related to their variation in trophic status, despite sharing the same source of water and found adjacent. Factors such as the incidence of solar radiation and water residence time may be the principal to determine these differences in primary production.

19-P   Is the worsening of droughts a threat for diatom diversity in Mediterranean streams?   *Elisa Falasco, Elena Piano, Francesca Bona*

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Mediterranean basin is considered a biodiversity hotspot in terms of species endemisms and degree of threat. Within this context, Mediterranean freshwater ecosystems are heavily endangered both at local and global scale, even more than terrestrial ones. An important role for the preservation of the biodiversity is played by the maintenance of the natural flow stability and water levels. Unfortunately, summer droughts are currently increasing due to the effect of climate change and human-related disturbances. Extremely low-flow periods cause a temporal and spatial increase of the dry stretches, during the hot months, and lead to habitat fragmentation, with the creation of isolated pools.
The focus of this research is to investigate the effect of hydrological disturbance on diatoms, the most important primary producers in streams. The specific aims are 1) to characterize the Mediterranean diatom flora both from taxonomical and ecological points of view; 2) to evaluate diatom biodiversity and the presence of threatened species under undisturbed (spring) and disturbed (summer) hydrological conditions, with a focus on their microhabitat selection; 3) to highlight the presence of potential new species with invasive behavior.
We selected 10 watercourses in Liguria (NW Italy), choosing 2 sampling sites in each stream: the first one characterized by permanent flow all over the year and the second one affected by intermittent flow during summer. Five sampling campaigns were carried out from April to September 2014. In each stretch we analyzed the main physical-chemical and hydrological parameters. Benthic diatoms were sampled following two different approaches in order to obtain as complete as possible a picture of diatom diversity.

Diatom flora characterizing the selected sites was mainly composed of β-mesosaprobous taxa, with a consistent percentage of taxa considered Endangered (following the Red List classification proposed for Germany). During the intermediate flow, the habitat heterogeneity played an important role for the conservation of these species; on the contrary, the habitat fragmentation which characterized the hot season caused a decrease of threatened taxa. During the survey, we detected species originally described as tropical taxa (*Cymbella tropica, Diadesmis confervacea, Navicula jakovljevicii*) or considered as allochthonous with an invasive behavior: *Achnanthidium delmontii* and *Didymosphenia geminata*. Moreover, we observed a decrease of the *nestedness* (spatial order of diatom meta-community) in those sites subject to seasonal water scarcity. Indeed the presence of generalist taxa and absence of specialist ones is expected to be more frequent in disturbed systems than in more stable ones.

19-P   Demographic responses of *Moina micrura* (Cladocera) exposed to the common pain-reliever, diclofenac administered through the alga (*Scenedesmus acutus*).   *Rosa Martha Moreno Gutiérrez [1] - S.S.S. Sarma [2] - Alma Socorro Sobrino Figueroa [3] - S. Nandini [2]*

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Diclofenac is among the most widely used pain-killers in Mexico. Since no medical prescription is needed to purchase this drug, its disposal, when expired, into domestic and hospital effluents is not well-monitored by governmental agencies. In this work we quantified the demographic responses of *Moina micrura*, a common cladoceran in Mexico, to diclofenac administered through the alga *Scenedemsus acutus*. The alga was incubated for 48 h in different concentrations (25, 50 and 100 mg/L) of diclofenac and centrifuged, rinsed and resuspended in moderately hardwater as the medium. The algae-loaded with the drug at chosen concentrations was offered as diet in cohort life table experiments using *M. micrura* neonates. Controls contained alga with diclofenac. Our results showed that demographic parameters (gross and net reproductive rates and the rate of population increase) of *M. micrura* exposed to alga containing the drug were significantly affected as compared to controls. In addition, increase in the exposure concentration of the drug to the algae had a greater adverse effect on the demographics of the tested cladoceran species. These results were discussed in relation to the effect of indirect exposure of cladocerans to drugs including nonsteroidal anti-inflammatory pharmaceuticals.

19-P   Revised nomenclature for cyanobacteria species' from slovakia and new additions.   *Thomas Smith, Ladislav Sallai*

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The purpose of this project is to revise the documented Cyanobacteria species' nomenclature from Slovakia and add new records documented. The up-to-date name changes were derived from the AlgaeBase internet resource (http://www.algaebase.org). The nomenclature reflects the current taxonomic understanding for previously recorded Cyanobacteria species. There are a total of 8 orders (Chroococcales, Chroococcidiopsidales, Nostocales, Oscillatoriales, Pleurocapsales, Pseudanabaenales, Spirulinales, Synechococcales). Nostocales had the most families at nine 9. Chroococcales had six 6 families, Oscillatoriales and Synechococcales had five 5 each, and Pleurocapsales had three 3, while Chroococcidiopsidales, Pseudanabaenales, Spirulinales had one 1 family, respectfully. There was a total of 501 species (146 Oscillatoriales, 129 Nostocales, 108 Synechococcales, 99 Chroococcales, 9 Pleurocapsales, 7 Pseudanabaenales, 2 Spirulinales, 1 Chroococcidiopsidales).

19-P   Consumption of *Microcystis* by the microcustaceans (*Simocephalus mixtus* and *Hyalella azteca*): an alternative to *Daphnia magna* in the control of cyanobacterial blooms in shallow lakes.   *Michael Anai Figueroa Sanchez [1] - S. Nandini [2] - Maria Elena Castellanos-Paez [3] - S.S.S. Sarma [2]*

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Lake management and biomanipulation studies have, for long, emphasized the need for large generalist grazers. Large cladocerans such as *Daphnia magna* (> 3500 μm) have been mainly responsible for the success in reduction of algal blooms. In tropical systems temperature favours the growth and permanence of cyanobacteria. On the other hand, the structure of the zooplankton community is composed of organisms with body size less than 1800 μm. Shallow water bodies in Mexico often have communities including the cladoceran *Simocephalus* and amphipodos such as *Hyalella* which have been observed in systems with presence of cyanobacteria. We compared the ingestion rate of *Simocephalus mixtus* (1350 μm) and *Hyalella azteca* (1770 to 2000 μm) fed *Chlorella vulgaris* and *Microcysti*s sp. at three different temperatures (20 and 30°C). It was observed that the amphipod consumed twice as much *Chlorella vulgaris* and *Microcysti*s sp. as the cladoceran at 30°C as compared to 20°C. Ingestion rates were lower in both test organisms on the cyanobacteria as compared to the green alga. Data are discussed with emphasis on the importance of testing a variety of organisms for controlling cyanobacteria in tropical systems as well as their susceptibility to fish predation all the year in the tropics.

19-P How to collect riverine diatom communities with an appropriate sampling frequency?

Naicheng Wu [1,2,3], Claas Faber[1], Xiuming Sun[1], Yueming Qu[1], Chao Wang[4], Snjezana Ivetic[5], Tenna Riis[3], Uta Ulrich[1] , Nicola Fohrer[1]

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There has been increasing interest in diatom based bio-assessment but up to now we still lack a comprehensive understanding of how to capture their temporal dynamics with an appropriate sampling frequency (ASF). To cover this research gap, the daily dynamics of diatom community were collected and analyzed over a 1-year period (25 April 2013 -30 April 2014) at a German lowland river. These 1-year sampling dates were classified into five time period clusters (1-5) by a Kohonen Self-Organizing Map (SOM) method based on similarity between species composition over time. To quantify the ASFs, community similarities (Percentage Similarity Index, PSI) for each pairing of successive days at each SOM cluster were calculated, and, as expected, PSIs decreased with increasing sampling interval. Based on a "cut-off" value (PSI=60%), the ASFs were determined to be 25 days and 13 days at Cluster 2 (06.-07.2013) and Cluster 5 (02.-04.2014), respectively, whereas no specific ASFs were found at Cluster 1 (04.-05.2013), 3 (08.-11.2013) (>30 days) and Cluster 5 (12.2013-01.2014) (< 1 day). Negative relationship between ASFs and hydrological wetness conditions (calculated as antecedent precipitation index API) was observed, suggesting that sampling interval should be reduced with increasing catchment wetness. Based on our results we recommend monthly sampling for low wetness periods when API < 23.0, biweekly sampling when API of 23.0-45.5, weekly sampling when API of 45.5-68.0, and daily or < 1 day (i.e. sub-daily, e.g., rain-event based sampling during high wet condition (API > 68.0). A key implication of our findings for freshwater management is that long-term bio-monitoring protocols should be developed with the knowledge of tracking algal temporal dynamics with an appropriate sampling frequency.

19-P Subfossil Cladoceras in large shallow lakes with intensive aquaculture along the Yangtze River, China: controlling factors of their distribution and environmental implications. *Xuhui Dong[1,2], Xiangdong Yang[2], Giri Kattel[3], Min Xu[2], Thomas A. Davidson[4],Erik Jeppesen[4]*

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Cladocera (Crustacea) are an essential component of the zooplankton and littoral zoobenthos of shallow lakes. Their importance as sentinels of environmental change in lakes has been well documented. Most of the studies on cladocera's distribution and ecology are based on European and North American lakes. In China, limited work has been conducted on this topic, particularly in the lakes from the Eastern China with strong human disturbance. In this study, the distribution pattern in cladoceran subfossils in the surface sediments of 62 shallow lakes in the middle and lower reaches of the Yangtze River Basin (MLYB) was examined. Multivariate methods, including regression trees and ordination, were applied to explore the relationships between the cladoceran taxa distribution and contemporary environmental variables. Partial constrained ordination of sub-fossil cladoceran assemblages indicated that both submerged macrophyte abundance and lake nutrient status (chla-a and total phosphorus concentration) significantly influenced community composition. The multivariate regression tree analysis also showed the distinct differences in cladoceran along the gradients of nutrient and the abundance of aquatic plant. The predation from fish, although extremely intensity of acute in these lakes, does not exhibit significant effects on cladocera's distribution. We assessed the potential of using cladocera for reconstructing historical ecological characters in MLYB lakes and identified various environmental indicators (*Bosimina longispina, Leydigia acanthocercoides, Leydigia leydigi, Chydorus sphaericus*).

19-P   Seasonal variations in biodiversity and abundance of phytoplankton in two lakes of Burabay National Park, Kazakhstan.   <u>*Dmitry Malashenkov*</u>*[1], Veronika Dashkova[1], Assel Sarsembekova[1], Kymbat Zhakupova[1], Natasha Barteneva [2]*

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Burabay National Park is located in the northern part of Kazakhstan and covers the territory with 14 lakes where Burabay and Shortan are among the largest lakes. Although national parks should act as reference areas and human impact is expected to be low, lakes Shortan and Burabay are pressured by increasing anthropogenic load associated with high recreation potential of the national park. This external factor is responsible for changes in structural and physiological properties of phytoplankton communities along with natural drivers in water ecosystems. If left unattended, lakes Shortan and Burabay may face problems including eutrophication, algal blooms, biodiversity loss and significant reduction of water quality in the next years.

The aim of the present study is to describe phytoplankton dynamics, structure and taxonomic composition and to assess water quality of two lakes (Shortan and Burabay) impacted by recreational load. Monthly samples were collected between June and September in 2014-2015 from 5 sampling locations for each lake and were analyzed using microscopy, flow cytometry and molecular techniques.

The phytoplankton diversity in Lake Shortan was represented by ten groups with a total number of 129 species observed. Among all the species, diatoms formed the most species-rich group making up to 47 species, whereas chlorophytes and dinoflagellates reached 26 and 11 species, respectively. Microscopy and flow cytometry cell sorting by FACSAria SORP cytometer (BD Biosciences, USA) with following analyses have shown that the most abundant groups are diatoms, chrysophytes (most notably *Dinobryon* species) and dinoflagellates. It was revealed that near-shore sulfate-rich locations coincide with high abundance of chlorophyll *a+c* containing phytoflagellates notably cryptomonads, dinoflagellates and chrysophytes. Phytoplankton assemblage in Lake Burabay was composed of 171 species from ten groups with chlorophytes (49 species), diatoms (45) and cyanoprokaryotes (34) being the most species-rich and abundant groups. The highest total abundance of phytoplankton in both lakes was observed in August when water temperature values were relatively high. During the summer, the percentage of small-celled colonial cyanoprokaryotes (including *Aphanocapsa* species) was increasing in ascending order with decreased proportion of diatoms from June to August in Lake Burabay. *Gonyostomum semen*, *Tetraëdriella jovettii* and *Goniochloris contorta* typical of small water bodies with low pH and coloured water were among new species that have not been observed in these lakes earlier. Our results showed that while Lake Shortan is an oligotrophic/oligo-mesotrophic reservoir with large distribution of oligosaprobic species such as *Ceratium hirundinella*, Lake Burabay has a mesotrophic status with ongoing eutrophication processes confirmed by the presence of species characteristic to eutrophic and hypertrophic conditions.

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20. LAND USE IN THE WATERSHEDS AND ITS EFFECT ON LAKES

20-O   Long-term changes in phosphorus cycling of a subtropical lake with special emphasis on man-made perturbations in the watershed and climate change.   *Werner Eckert, Aminadav Nishri*

The Yigal Allon Kinneret Limnological Laboratory, Israel Oceanographic and Limnological Research, Migdal

Our study on the phosphorous (P) cycle of Lake Kinneret presents an overview of more than 40 years of research and monitoring while following up earlier published assessments on P-partitioning, sedimentation and diagenesis. The P evolution in the water column is described based on understanding of physical forcing processes and their role in internal P-loading. Our results point towards a novel transport mechanism that is responsible for the depletion of SRP in the hypolimnion. A whole-lake mass balance model, based on data from the 1970s, is updated according to the annual P-fluxes measured later-on while taking into consideration previously neglected components such as aeolian P inputs. Our long-term trends indicate dramatic changes in the TP-inventory. Between the early eighties and the early 2000s the TP content of Lake Kinneret dropped by 30%. The observed drop is linked to man-made perturbations in the watershed that led to a gradual reduction of allochthonous inputs and internal P-loads. The relationship between the observed changes in P loading rates and changes observed in the Lake Kinneret ecosystem is discussed.

20-O   Crop-residue sourced organic matter pulses cause hypoxic blackwater events in eutrophic freshwater agricultural watershed bayous.   *Richard Lizotte, Jason Taylor, Martin Locke*

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Substantial research has established that aquatic ecosystems in watersheds with intensive row-crop agriculture are vulnerable to ecological impairment associated with non-point source runoff of nutrients and sediments. Much less is known about the role of crop-sourced dissolved organic matter (DOM) pulses in causing hypoxic blackwater events in these eutrophic systems. We assessed diel dissolved oxygen (D.O.), dissolved organic carbon (DOC), and precipitation in three low gradient, low flow stream bayous in agricultural watersheds of northwestern Mississippi, USA from 2011-2014. Between the months of June and October, which preceded autumn deciduous tree leaf fall, a total of 18 hypoxic events associated with elevated DOC following rainfall events were observed. Significant D.O. sags were associated with the influx of DOM measured as DOC. Thirteen events occurred from July to September coinciding with the driest time of the year, annual instream low flow periods, and drying of crops in preparation for harvest. Duration of stream bayou hypoxic events ranged from a few hours (4-8) to several days (2-7) with the most severe events eliciting anoxia typically occurring in shallower upstream channels. Stream mesocosm experiments using corn (*Zea mays*) residue and varying hydrological conditions were conducted to further elucidate crop-residue sourced DOM pulses eliciting stream hypoxia. Mesocosm results indicated that corn-residue elicited hypoxia within 12-24 h of DOM dosing and average duration of hypoxic events ranged from 12 to 42 h depending on DOC concentration (12-17 mg DOC/L). Mesocosm hydrologic manipulations showed that increased flow increased the amount of DOC needed to cause hypoxia and decreased the time for D.O. concentrations to recover. In contrast, drought conditions did not significantly affect the magnitude or duration of hypoxia. Our results indicate that reduction of DOC pulsed inputs to low-flow aquatic habitats is necessary to mitigate hypoxic blackwater events and improve summer to early fall D.O. concentrations in agricultural stream bayous.

20-O   Spatial variation in fatty acid composition of fish food sources in subtropical rivers: implications to conservation.   *Juan Tao, Mark J. Kennard, Stuart E. Bunn*

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Fatty acids (FAs) play an important role in aquatic food webs. However, FA profiles of food sources are limited understood across taxa and spatial scale in rivers. Identify the effects of environmental factors on FA availability for fish and other animal consumers are critical in the aquatic ecosystem conservation and management under the intensified human disturbance. In this study, we analysed the FA composition of nine basic food sources collected from eight sites

with nature longitudinal and human disturbance induced gradients in two subtropical rivers, South-east Queensland, Australia. Partial redundancy analysis (pRDA) was conducted to separate the effects of taxa identity and environmental gradients (site). Taxa identity and site together explained 60.1% of FA variation, while taxa identity alone contributed 86.9% of the explained variation. Environmental factors only contributed 12.8 % of the explained variation, and the rest (0.3%) was accounted by their joint effects. However, repeated redundancy analyses (RDA) found that most of FA variation for a particular food source across sites can be explained by environmental factors. Different food sources have distinctive FA profiles, and high unsaturated fatty acids (HUFA) show an obvious bio-accumulation along the trophic level increasing. Our findings highlight that, the FA composition of food sources largely different because of the effects of taxa identity. Environmental factors have very limited effects on FA composition at community or ecosystem scale, but dominantly affect the FA composition of a specific food source in studied rivers. Ecologically, conservation and management strategies from a FA view should be adapted with considering the priority on which organism levels.

20-O   Changes in macroinvertebrate community structure of small streams in agricultural catchments in response to nutrient concentrations.   _Stephen Davis_ [1] - _Mary Kelly-Quinn_ [2] - _Mairead Shore_ [3] - _Per-Erik Mellander_ [3] - _Daire Ó hUallacháin_ [4]

Teagasc, UCD, Dublin, Ireland [1] _- School of Biology And Environmental Science, University College Dublin, Dublin, Ireland_ [2] _- Agricultural Catchments Programme, Teagasc, Wexford, Ireland_ [3] _- Teagasc, Wexford, Ireland_ [4]

The widespread decline in global biodiversity represents a major conservation challenge. In an effort to address this challenge, the Water Framework Directive aims to achieve and maintain high ecological status in water bodies. In Ireland, the two main threats to water quality are nutrient transfers from municipal and agricultural sources. Diffuse nutrient losses from agriculture are closely linked with storm events, which tend to be most prevalent in winter, whereas municipal point sources pose a chronic pressure, particularly during summer baseflows when dilution effects are minimal.
This study aimed to describe seasonal variations in freshwater ecological communities in five agricultural catchments in Ireland, and identify the main pressures influencing community structure. Three grassland catchments and two arable catchments were selected to represent the main intensive agricultural practices in Ireland. Water chemistry and aquatic macroinvertebrate data, collected as part of the Agricultural Catchments Programme, were analysed from the five catchments. Snapshot water chemistry data were collected on a monthly basis between 2009 and 2014. Macroinvertebrate kick samples were collected every May and September over the same period. Chemical and ecological data were analysed, to identify seasonal patterns in water quality and determine how hydrochemical parameters influenced macroinvertebrate community composition and structure.
This study found that there were significant variations in relation to macroinvertebrate community structure between May and September. Variations were particularly evident with richness and abundance of A-class species (those classed as pollution sensitive in the Q-value system), and the abundance of EPT (Ephemeroptera, Plecoptera and Trichoptera) taxa. The change in community structure, from communities containing sensitive species such as _Rhithrogena semicolorata_ and _Chloroperla sp._ in spring, to communities containing more tolerant species such as _Rhyacophila dorsalis_ and _Micropterna sp_. in summer, correlated with periods of elevated phosphorus (P) concentrations during summer baseflows. These results could suggest that these streams are P limited and that periods of high P concentrations during the summer are impacting the ecological community of the streams.

20-O   Modelling the impact of catchment land-use on cyanobacteria blooms in an urban tropical lake.   _Talita Silva_ [1] - _Brigitte Vinçon-Leite_ [2] - _Guido Petrucci_ [3] - _Bruno Lemaire_ [2] - _Viet Tran Khac_ [2] - _Lorena Avelina Rojas Gutierrez_ [2] - _Nilo Nascimento_ [1]

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In urbanizing areas, increasing imperviousness is responsible for rising runoff volumes and erosion, leading to greater nutrient and pollutant loads into downstream water bodies. This leads to eutrophication and proliferations of

cyanobacteria, harmful for human and animal health. In order to protect surface water resources, water management stakeholders need tools to forecast the impact of urban stormwater on downstream ecosystems taking into account different mitigation scenarios, such as the improvement of sanitation or the reduction of runoff.

Our objective was to set up such a modelling tool, coupling a hydrological model of the catchment and a physical-ecological model of the lake. The study site is Lake Pampulha, Brazil. The lake and its catchment were intensively monitored from October 2011 to October 2014. This data set was used for the parameter calibration and validation of both models. The hydrological model provided good results for the runoff quantity and an acceptable agreement with field measurements for the runoff quality. The lake ecological model successfully represented the cyanobacteria dynamics. A sensitivity analysis of the coupled catchment-lake model was used to investigate its ability to simulate scenarios of changes in the catchment, namely the reduction of phosphorus loading corresponding to an improvement of sanitation efficiency and the increase of impervious cover due to catchment urbanization. Impervious cover appeared as the more sensitive driver of cyanobacteria biomass.

One option to mitigate the impact of impervious cover, without limiting future urbanization, is the introduction of nature-based stormwater control in the catchment. Green Blue Infrastructure (GBI), an interconnected network of natural and artificial green spaces and water bodies within urban areas, can play an important role for the protection of water resources. The analysis of land use and land characteristics like, for instance, topography, water table depth and pedology, makes it possible to identify types of GBI that can be implemented in each land use patch. This analysis was carried out for a pilot sub-catchment and the results of the coupled catchment-lake model were compared between the current "reference" situation and a scenario including GBI implementation. Extending this methodology to the whole catchment will allow us to identify the best management strategies for land use in the catchment.

20-O   Disentangling multi-scale environmental effects on stream microbial communities.   *Jenny Jyrkänkallio-Mikkola* [1] *- Janne Soininen* [1] *- Jani Heino* [2]

University of Helsinki, University of Helsinki, Helsinki, Finland [1] *- Finnish Environment Institute, Natural Environment Centre, Biodiversity, Oulu, Finland* [2]

Microbial stream communities have a pivotal role in nutrient cycling and ecosystem functioning. Yet the influence of anthropogenic activities on aquatic microbial biodiversity has received little attention compared with terrestrial macro-organisms. Intensive agriculture may lead to changes in stream microbial composition and diversity via elevated nutrient levels and turbidity. Although local environmental factors are widely known to shape benthic microbial communities, some studies have also indicated the importance of spatial processes and climatic variables affecting aquatic microbial diversity. It is likely that spatial scale of the study determines which variables are most important in defining microbial communities. Thus, understanding the mechanisms that control stream microbial biodiversity requires considering not only local or geographical drivers, but also drivers at catchment level. In the present study we aim to disentangle the effects shaping stream diatom and bacterial communities at scale covering 63°-66°N and 22°-27°E in Finland. We will use dataset collected from 105 independent boreal streams and we will examine the effects at four levels:
1) local level that incorporates water chemistry and physical variables
2) catchment level that includes land use characteristics and soil properties
3) climate level including relevant climatic variables
4) pure spatial factors

We expect to find a significant relationship between microbial communities and water chemistry. We hypothesize that agriculture will have a substantial effect on diatom communities suggesting that catchment characteristics may act as valuable proxies explaining microbial community variation. We will also expect to detect an effect between climatic variables and diatom communities at present study scale. Finally, we expect to find geographical trends in diatom and bacteria distribution which would possibly indicate dispersal limitation in microorganisms. Few studies have simultaneously addressed local, catchment-level, geographical and climate effects on stream microbial communities. We will compare diversity patterns along catchment land use gradients for diatom and bacterial community samples by addressing species richness and community structure.

20-O   Land uses and freshwater system quality of Oglio River sublacual basin (Northern Italy).

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Quantifying the effects of land use and other multiple stressors, that may also act in synergy, on freshwater ecosystems is challenging, due to the complex interactions within blue water components (groundwater, lakes, rivers, springs) and to the lack of tailored field campaigns for the contemporaneous measurement of hydrological, chemical and ecological parameters. A wealth of available studies addresses a single stressor separately without exploring their concurrent effect. However, concurrent effects with several stressors, such as the release of pollutants from agricultural or industrial activities and waste water treatment plants, have not been explored at depth, so far. Additional pressures are also being exerted by population growth, urban expansion, and industrial development. The anthropogenic pressure on water resources is growing worldwide, and reducing its effects on the water 'availability' and quality is one of the major societal challenges.

We present a part of study (Fondazione Cariplo grant n° 82014-1282) on the land uses and their impacts on blue water of the Oglio River sublacual basin. The research project aims to analyze the processes that affect blue water quality and quantity with a key focus on the interactions within its different components using the inter-disciplinary approach. The attention is focused on a typical alluvial basin in the Po Plain (Lombardy Region – Northern Italy), that is heavily impacted by land uses and, in general, anthropogenic activities, where the blue water system is composed of subalpine lakes, rivers, irrigation and drainage channels, springs and unconfined and confined aquifers, all interacting with each other. The study area shows a significant variability in terms of land and water use and hydrological driving forces: this allows us to use this basin as a benchmark for testing and validating models of ecological functioning, pollutant cycling as well as the effects of new water policies and water management strategies.

The results concern integrate information and dataset, continuous in space and time, systematically collected by a 'multitasking' group (UNIMIB) with several expertise over the past year for a comprehensive investigation of blue water dynamics. More than 60 sampling sites have been monitored seasonally, measuring hydrological, hydrochemical (ions, nutrients, heavy metals) and isotopic features on the lake, river, aquifer, and springs to develop a three-dimensional numerical flow model producing a quantitative water balance to evaluate the sources of water, the travel time and the mixing degree between surface water and groundwater, and among the confined aquifers.

20-O   The importance of deciduous forest for alkalinity, phosphorus burial and isoetid macrophytes as revealed by a recent paleo study in a soft water Lobelia Lake (Grane Langsø, Denmark).   *Anna-Marie Klamt* [1] *- Kasper Reitzel* [1] *- Morten F. Mortensen* [2] *- Norman Schreiber* [3] *- Henning S. Jensen* [1]

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Lake Grane Langsø is characterized by nutrient-poor soft water with very high visibilities and hence contains rare isoetid species (such as *Isoetes lacustris*, *Littorella uniflora* and *Lobelia dortmanna*). Pollen data and old maps show that the dominating vegetation in the catchment area of Lake Grane Langsø changed during the last ca. 200 years from deciduous forest to open heathland with some agriculture and afterwards to coniferous forest. To determine the effects of these changes on the lake, macrofossils, metals and different phosphorus (P) forms were analyzed in dated short sediment cores from the deepest site of the lake. The proxies revealed diverse changes in the lake's conditions and species composition: 1) The removal of deciduous trees seemingly reduced the calcium supply to Lake Grane Langsø and thereby the lake's buffering capacity. This development is accompanied by decreased amounts in macrofossils of calcium (Ca)-sensitive species (as reflected in *Daphnia* ephippia and *Cristatella mucedo* statoblasts) and followed by increases in acidophilic species (as reflected in *Juncus* seeds and *Sphagnum* leaves). 2) The contents of organic material and organic P forms were clearly lower in sediments that were deposited during the period of least forest cover. Especially humic bound P seems to be positively related to the presence of deciduous trees which may be linked to a stabilizing effect of calcium. 3) An erosion event (as reflected in *Cenococccum geophilum* sclerotia) during the open-land period clearly reduced the amounts of macrofossils for *Isoetes* sp., *Lobelia* sp. and Characeans. This suggests a reduction in their maximum distribution depth because of enhanced influx of terrestrial material and subsequently reduced water transparencies. Overall this paleo-study underlines the sensitivity of nutrient-poor soft water lakes to changes in their catchments vegetation and their partial irreversible consequences and is therefore of importance for lake management.

20-O   A decision support system to identify lakes that are likely to respond to mitigation measures aimed at reducing diffuse pollution from agricultural sources.   *Linda May* [1] *- Philip Taylor* [1] *- David Skirvin* [2] *- Bryan Spears* [1] *- Pamela Naden* [3] *- Adrian Collins* [4]

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Many lakes in Europe have water quality targets set under the EU Water Framework Directive (WFD) (EC WFD, 2000). In England and Wales, the Environment Agency monitors these lakes for regulatory purposes and the data collected show that many are still failing to meet required standards. Although some failures are due to invasive species and problems with aquatic plant communities, the majority are due to eutrophication caused by excessive amounts of nutrients entering lakes from their catchments. A particular problem is total phosphorus (TP), a major chemical constituent of agricultural runoff and sewage effluent.

The main aim of this study was to identify lakes across England and Wales that were failing WFD targets for TP concentrations and determine where these problems could, potentially, be solved by reducing TP inputs from agricultural sources. Using a combination of measured data and modelling approaches, we:
- identified lakes that were failing WFD targets for TP concentrations
- calculated the critical level of TP inputs to these lakes that, if exceeded, would be likely to cause failure of WFD TP targets
- determined whether reducing TP losses from agricultural sources would reduce TP inputs to lakes sufficiently for water quality targets to be met
- highlighted lakes where high levels of resilience to change would probably delay, or even prevent, recovery if TP inputs from agricultural sources were reduced significantly

We found that, even with a 100% reduction in the TP load from agricultural sources, 68% of failing lakes within England and Wales would still not meet the WFD criteria for good ecological status, and 56% would still not meet the WFD criteria for moderate ecological status. This was due to high levels of TP entering lakes from other sources within their catchments, mainly related to inputs from sewage-related sources such as waste water treatment works and septic tanks. We also found that many of the degraded lake were likely to be affected by factors that would tend to delay recovery once TP inputs had been reduced. These include high levels of internal recycling of TP, shallow depths, short wind fetch, very low flushing rates and the presence of benthivorous fish.

A decision support system was developed to identify lakes that were likely to respond to the implementation of mitigation measures to reduce agricultural runoff. This suggested that, of the 750 lakes considered, only 23 had the potential to achieve WFD water quality targets if external TP loads from agricultural sources were reduced, and that only 12 of those were likely to recover quickly. Even then, this level of recovery could only be achieved if TP inputs from agricultural sources were reduced by 100%. The results show that, in most cases, reducing the external TP load from agricultural sources would be an effective means of improving lake water quality to the required standard only if it was introduced as part of broader programme restoration measures.

20-O   The widespread salinization of rivers in a mixed land-use river basin in Western Canada.
Jason Kerr

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Salinization is an increase in the concentration of salts in aquatic ecosystems and is a problem in freshwaters globally. Due to its toxicity to freshwater biota, chloride (Cl^-) is a major concern in waters exhibiting increased salinity. Anthropogenic sources of Cl^- to rivers include irrigation return flows, land clearing, wastewater effluent, oil and gas activities, and in northern latitudes, the application of road salt. While urbanization, and more specifically the application of road salt is increasingly recognised as an important source of Cl^- to streams and rivers, there is a paucity of data examining the extent to which urbanization has impacted long-term Cl^- trends in large, mixed land-use river basins. In this study, data from 12 long-term (>15 years) riverine monitoring stations in the South Saskatchewan River Basin (SSRB), in Alberta, Canada were examined for spatial variability and temporal trends in Cl^- concentration.

At 11 of the 12 stations, seasonal Mann Kendall (SMK) trend analysis on raw concentration data (i.e., data not flow-weighted) showed a significant ($P < 0.05$) increase in Cl^- concentration over time. Importantly, Cl^- showed a significant ($P < 0.05$) negative relationship with flow across the basin and flow during the period of investigation increased in all

rivers. When SMK analysis was performed on flow adjusted values, a significant increase in Cl^- concentration was observed at all 12 stations indicating that the observed trends were not the result of a concentration effect but rather the result of increased watershed inputs to the river system over time. In terms of spatial variability across the basin, significant differences ($P < 0.05$) in salt chemistry were observed between stations upstream and downstream of major urban centres. A distinct "urban signal" consistent with road salt application was observed. Relative to upstream sites, stations downstream of major urban centres exhibited higher Cl^- concentrations, a higher sodium adsorption ratio (SAR), higher $Cl^-:SO_4^{2-}$ and $Cl^-:HCO_3^-$ ratios, and Na:Cl ratios closer to 1. Importantly, this urban signal was also observed in the temporal trends, with significant shifts towards a stronger urban signal observed over the past 15-30 years. While a number of potential sources of Cl^- exist within the SSRB, the data indicate that increased urbanisation, and in particular an increase in the application of road salts, has been a major factor in the salinization of the regions major river systems. This study adds to a growing weight of evidence highlighting the risk to aquatic ecosystems posed by the increased urbanisation of watersheds in cold regions where the application of road salt is a major component of winter road maintenance.

20-O   Outbreak of *Pectinatella magnifica* (Leidy, 1851) in large river ecosystems, South Korea: distribution of statoblast and colony.   *Eui-Jeong Ko [1] - Hyun-Bin Jo [1] - Yuno Do [1] - Hyun-Woo Kim [2] - Seong-Ki Kim [1] - Jeong-Soo Gim [1] - Gea-Jae Joo [1]*

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In summer of 2014 and 2015 in South Korea, the invasive freshwater bryozoan (*Pectinatella magnifica*, Leidy 1851) exhibited an outbreak in four large regulated rivers. The outbreak became a national ecological issue due to its appearance and the accompanying odor. To this point, surveys of the species have focused on the colonies and their structure. This study examined the possibility of statoblasts contributing to colony expansion. In this study, therefore, we conducted a nationwide river survey of *P. magnifica* colonies including statoblast occurrence to provide more accurate distribution information. A total 52 sites were surveyed in 4 large rivers in summer (June) and fall (September) 2015 (Han R. n=14, Geum R. n=11, Yeongsan R. n=11, Nakdong R. n=16). To find colonies of *P. magnifica*, the littoral zone of each study site was examined up to 1m depth, along a 100m long riverside transect. To complement this survey, free-floating statoblasts were collected using anchored Styrofoam boards. Hydrological factors were collected from public databases. Colonies were found in all river systems. The Han R., had the lowest frequency of colony appearance (7.14%, only one site we found). The other rivers, *P. magnifica* exhibited more than 50% dominance. The statoblasts were collected from 45 sites (86.5%). Although the Han R. shows a relatively low proportion of colony distribution, it had the highest abundance of statoblasts found (46.5 per site). Compared to average rainfall (1320 mm, S.D= 304) for 26 years the last two years, 2014 and 2015 both had droughts (1013 mm, S.D= 192). Water temperature (20.7℃, S.D= 4.6) from April to October over the previous 23 years favorable for *P. magnifica* (more than 20℃) growth. Our study provides only a snapshot regarding *P. magnifica* colonization, but it also describes the potential distribution of *P. magnifica* using statoblast data. Low rainfall, constructed weirs and warm water temperatures in summer are suitable for this species. Therefore, germination is possible throughout the river drainages. We find this invasive species will not only affect large river ecosystems but also has the potential to invade their tributaries nationwide.

20-O   Effects of aquaculture fish enclosures on phosphorus retention and trophic state in a lignite mining lake.   *Björn Grüneberg [1] - Frank Rümmler [2] - Dieter Lessmann [3]*

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We studied a small (A 25.8 ha; z_m 3.4 m) oligotrophic mining lake in Lusatia (Germany) which receives ~ 14 t/yr of high-energy fish feed to grow carp in enclosures. The former acidic lake was chemically neutralized by liming in 2009 and is still influenced by the inflow of acidic groundwater with high iron concentrations.
To track the fate of the food phosphorus (P) within the lake we developed a complete P budget based on the calculations of feed input and fish removal, quantification of gross sedimentation rate by traps and net sedimentation rate by

sediment analysis, P release by desorption experiments and sequential extraction, and sediment fluxes from pore water analyses.

The P areal load due to fish feed (0.8 g m^{-2} a^{-2}) was about ten times higher than the natural P load. Aquaculture effects like anoxic conditions, elevated P- and organic carbon contents in sediments and elevated P- and NH$_4$-release rates from sediments were detected only in the immediate vicinity and directly below the fish enclosures. Fish initially ingested the food almost completely, but only 29 % of feed P was incorporated permanently and removed from the system. 70 % of feed P was thus excreted mainly as faeces. 26 % of feed P was measured as gross sedimentation, and 45 % was recycled in dissolved form into the lake water. Despite this high P supply, we did not detect an increase of lake P concentrations or phytoplankton productivity. The results show that lignite mining lakes have the potential for a high resilience to elevated P loading due to iron import via groundwater. The resilience of mining affected lakes makes them especially suitable for aquaculture as long as P loading is balanced by constant supply of extra P sorption capacity by iron import.

20-O   Impacts of land-use disturbances on biodiversity and consumer-resource interactions in riverine ecosystems.   *Yixin Zhang*

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The impact of land-use disturbances on aquatic biodiversity and consumer-resource interactions in river and riparian ecosystems is one of major ecological topics for ecosystem conservation and management. Disturbances caused by land-use change are a global environmental issue with cumulative ecosystem effects across geographic regions. We conducted studies investigating relationships of land-use disturbances, stream habitat conditions, and benthic invertebrates in rivers located in different geographic regions in three continents, including central and northern Sweden, coastal British Columbia in Canada, southern China, and central Texas in US. We analyzed large data sets to determine the impacts of different landscape disturbances (damming, forest harvesting, agriculture, and urbanization) along with other environmental variable changes on benthic biodiversity. Using partial least squares projection to latent structures (PLS) modeling, we assessed relationships between multiple environmental variables, benthic communities and consumer-resource Interactions. In Sweden, we found that hydraulic disturbance caused by flow regulation greatly influenced benthic community assemblages and ecological interactions between consumers and resources. Disturbance caused by forest harvesting had a strong negative effect on benthic biodiversity. In coastal British Columbia of Canada, data showed that benthos' biomasses at previously logged sites were significantly lower than those at reference sites. A legacy of measurable forest harvesting impacts on benthic diversity in streams was detected up to 40 years after logging at catchment scale. In China, we found that urbanization through total impervious area (TIA, % of total urban/rural areas within a catchment) was negatively related to water quality index in rivers we studied. PLS models showed that benthic richness and relative abundance of macroinvertebrates were negatively correlated with TIA and positively with water quality index. Land-use disturbance by urbanization severely degraded riparian and river ecosystem integrity. In central Texas of US, results of PLS analysis of watersheds revealed negative relationships between TIA and bio-indicators (benthic macroinvertebrate and diatom indices). Environmental indicators (water quality, sediment quality, and physical integrity) indicated the impact of land-use disturbance through urbanization in the watersheds on stream ecosystems. In summary, these studies across geographic regions revealed that landscape indicators incorporating land-use disturbances and historical land-use offer promise to assess biodiversity status and consumer-resource interactions in riverine ecosystems.

20-O   Using networks to detect aquatic transitions in aquatic communities across a landscape of human impact.   *Zofia Ecaterina Taranu , Amanda Winegardner , Mohamad Elmasri , Sarah Baldwin , Julien Roger , Max Farrell , Eraclis Araclides , Timothée Poisot ,Russel Steele l, Irene Gregory-Eaves , Pierre Legendre*

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Anthropogenic stress to aquatic ecosystems can result in ecosystem-level shifts that are difficult to predict, hard to reverse and have undesirable consequences on communities. Within this context, there is considerable interest in identifying the response of aquatic ecosystem to environmental change (gradual vs. rapid transition). In this work, we

applied network analysis to capture interactions among organisms and test for the support of a bifurcated response in aquatic ecosystem across a landscape of human impact. We expected rapid changes in ecosystem state across the landscape if food webs consisted mostly of highly connected and functionally redundant species. These networks would dissipate local disturbances quickly and provide resistance to change at first until reaching a threshold, at which point, a critical transition would occur. In contrast, we expected a gradual response to environmental stressors if food webs were predominantly comprised of low connectivity, heterogeneous species. Using a subset of lakes from the USEPA's National Lake Assessment data, we thus set out to quantify how aquatic food webs varied across broad spatial gradients of land use, eutrophication and temperature. Preliminary results indicate that certain network properties vary nonlinearly with respect to nutrient enrichment.

20-P   Limnological development of a small mining lake after chemical neutralisation and under the use for fish production.

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In Germany's Lusatian opencast mining district a high number of new lakes have developed after the abandoning of lignite mines and the re-increase of the groundwater. Many lakes are acidic due to pyrite oxidation in the adjacent overburden dumps. However, there is a high interest in multiple uses of these lakes, which often require a neutralisation of the water body. This includes lakes that are considered for fish production in aquaculture enclosures.
Lake Tröbitz 122 is one of the smaller mostly polymictic mining lakes with an area of 25.8 ha, a volume of 0.9 Mio m³ and maximum depth of 7.4 m. The lake was chemically neutralised with lime in 2009. Since 2011, fish enclosures have been installed on the lake with a yearly capacity of up to 15 t of carp production. Against the background of high nutrient input from fish production and the still continuing inflow of acidic and iron-rich groundwater, the limnological development of the lake has been investigated in a long-term monitoring programme.
The gradual re-acidification made a second application of lime necessary in spring 2013. Despite the high nutrient input, phosphorus concentrations in the main water body remained in the oligotrophic range (about 6 µg/L TP). Increased nutrient concentrations occurred in a small hypolimnion during short-term stratification periods in summer with about 30 µg/L TP and 720 µg/L NH_4-N.
The phytoplankton biocoenosis rapidly responded to the changes in pH with an increase in species number under pH neutral conditions. The year-to-year changes in species composition resemble the primary succession in newly formed lakes. There is a general tendency to more balanced dominance structures over time. The development of the phytoplankton will be analysed in detail with regard to the changes in pH and the changes in the temporal and spatial availability of resources.

20-P   Accumulation of iron and manganese and their effects on growth parameters in juvenile common carp (_Cyprinus carpio_).

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Metals can deposit in the water over time, which can accumulate in the aquatic plants and organs of benthic organisms. Vertebrates of the aquatic ecosystem, such as fish, frogs and toads will be excellent indicators of metal pollutions.
In this study, Fe and Mn accumulation were investigated in the organs of common carp (_Cyprinus carpio_). The experiment was carried out for 49 days where 5 treatments were used with 18 carp juveniles in each treatment. Within one treatment 3 replicates were applied. The growth parameters and survival was studied as well as 3 juveniles were sampled from each aquarium. The concentration of Cu, Fe, K, Mg, Mn, Na, Sr and Zn were analysed in the liver, eyes, brain, muscular tissue and gills of randomly separated juveniles with microwave plasma atomic emission spectrometer (Agilent MP-AES 4100). Certified reference material was used (ERM-BB422, fish muscle) during the measurement. The analytical error was less than ±10% of the certified values for the metals.

Significant difference was not found among treatment based on the survival data. Significant difference was found in the body weight only between control (tap water) and fourth treatment (Fe: 1.50 mg L^{-1}, Mn: 0.625 mg L^{-1}). The largest amounts of iron and manganese accumulated in the liver and brain of fish, while the minimum concentrations were measured in the muscle tissue and the gills. Statistically higher concentrations of iron and manganese were found in the brain, the muscle tissue and the gill only on the fourth treatment (Fe: 1.50 mg L^{-1}, Mn: 0.625mg L^{-1}). Our results demonstrated that only the high manganese concentration had significant effect based on the elemental concentration of metals in liver.

In summary, our study demonstrated that the iron and manganese concentrations had not negative influence on the growth of the carp juveniles. At the same time, our results indicated that metal accumulation was started in almost all organs, but the studied concentrations and studied exposure times did not cause damages in organs of carp juveniles. The increase of concentration iron and manganese had absolute positive effect and did not have negatively effect on the survival of fish.

20-P   Multi-taxonomic biodiversity in aquatic ecosystems along land use gradients: a study across Europe.

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According to the Millennium Ecosystem Assessment, habitat change brought by land use alteration is one of the main drivers of biodiversity loss. In a global change scenario, understanding the way in which anthropic land use types may affect biodiversity is becoming increasingly relevant for the conservation of ecosystem functionality. In particular, land use changes affect aquatic ecosystems via multiple processes, acting at different spatial scales and influencing the aquatic biota.

Most empirical and theoretical biodiversity studies focus on the diversity of a restricted number of organisms (both taxonomical and functional groups); moreover, information on diversity patterns across different trophic levels is scarce. In this work, we examined the effect of anthropic land uses on different aquatic organisms, in both lotic and lentic ecosystems, in the framework of the " FIAT Biodiversity Value Index (BVI)" project.

We selected eight industrial plants of FIAT Group distributed across Europe in Italy, France, Germany, Spain, and Serbia. All study sites were located in the nearby of one or more Natura 2000 sites. A study buffer was defined as a 5 km radius circumference, with the centre located in the industrial plant. We focused on the two main aquatic components inside the buffer: lotic and lentic ecosystems. We selected four bioindicators which could be representative of the whole biodiversity status, namely odonata, amphibians, macrophytes and diatoms. For each biological component, we identified 10 sampling points mainly located in the Natura 2000 sites, and organisms were sampled according to standard protocols.

For each buffer we calculated the percentage of the different anthropic land uses, namely urban, agricultural (intensive and extensive) and industrial. We tested each land use variable against specific richness of each bioindicator via generalized linear mixed models (GLMMs). We also tested the relationship between composition of the communities and land uses via redundancy analysis (RDA). All statistical analyses were performed in R environment.

Results showed that land uses significantly affect the communities of all the considered taxonomic groups. Specifically, according to RDA, community composition was always significantly affected by the different land use types. We also highlighted a different response of specific richness of bioindicators to the different land use types, with diatoms being negatively affected by industrial land use and favoured by naturality, while dragonflies proved to be negatively affected by intensive agriculture. In light of our results, we discuss the importance of evaluating multiple indicators in biodiversity monitoring programs.

20-P   Constructed wetlands for agricultural runoff remediation – effects on bioavailability of phosphorus.

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Agricultural runoff is a major contributor to the eutrophication of waters in the Jæren region in the Southwestern part of Norway. One remedial action has been to construct artificial wetlands (constructed wetlands) for handling runoff from diffuse sources as well as point sources, under the general assumption that constructed wetlands will remove a

substantial fraction of nutrients. However, not much evidence exists that the several hundred constructed wetlands in this region have had the intended effects, and very little improvement of water quality is evident in monitoring data.
A project is underway to evaluate to what extent constructed wetlands are reducing the phosphorus loading to our local waters, and how they should be designed for optimum removal of phosphorus.
One part of this project focuses on the effect of the constructed wetlands on the phosphorus fractions and the bioavailability of phosphorus in runoff water. Based on results from algae assays, the seasonal change of the bioavailability of phosphorus through the constructed wetlands is discussed, as are the implications for the eutrophic state of receiving waters.

20-P   The effect of paddy field using water pumped from Lake Biwa on forming blue-green algal bloom.   _Shoko Hosoi_

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Lake Biwa is the largest freshwater lake in Japan with an area of 670km^2 and the deepest point of 140m below. This lake is known as one of the world's precious few ancient lakes, with four million years of history. The watersheds around this lake is known as the rice - producing distinct, and 90% of a total of 600 km^2 of farmland in this area is paddy fields. For many years, people in most parts of this area have suffered from water shortage for rice cultivation. Therefore, pumping facilities to lift the lake water were established widely over this area, and rice cultivation mainly used the pumped lake water now. In this system, the pumped lake water as irrigation enter the paddy where includes much amount of nutrients such as nitrogen and phosphorus, and all the drainage water from paddy fields runs through drainage ditches directly into the Lake Biwa. Therefore, the paddy field might contribute to the bloom of phytoplankton in Lake Biwa by culturing the irrigation pumped from Lake Biwa. In this study, the effect of paddy field using water pumped from lake Biwa on forming blue-green algal bloom on the basis of microscopic analysis and molecular technique. Analysis of several environmental parameters (water temperature, NH_4-N, NO_3-N, NO_2-N, PO_4-P, D-Fe, and Chl. a) showed that the water of paddy field was high temperature and contained the high concentration of N, P and D-Fe. However, the cell density and diversity of phytoplankton in the paddy field was lower than that in the irrigation, which was pumped up from Lake Biwa. Moreover, some of cyanobacteria in the irrigation disappeared in the paddy field and drainage water, indicating that it is difficult for the phytoplankton including cyanobacteria to grow in the paddy field and repress the bloom of phytoplankton in the paddy field. The paddy field might just give the water including the much amount of N, P and D-Fe, being responsible for the bloom in the down stream and lake Biwa.

20-P   The relationships among environmental variables, land use patterns and microbial metabolism in the river sediments of three slovenian rivers.   _Barbara Debeljak_ [1] _- Nataša Mori_ [2] _- Tatjana Simčič_ [2] _- Anton Brancelj_ [1]

National Institute of Biology, University of Nova Gorica, Ljubljana, Slovenia [1] _- National Institute of Biology, Ljubljana, Slovenia_ [2]

River sediments have been recognised for their functional significance for the whole stream metabolism. Due to importance of microbial processes in the river sediments for ecosystem functioning it is important to consider them in the assessment of river condition. The present study aimed to test the relationships between environmental variables, land use patterns and biofilm biomass and activity. Biofilm biomass and activity were investigated in surface and hyporheic sediments in spring 2014. The study area included three rivers and nine sampling sites in the central part of Slovenia. Each sampling site was selected according prevailing land use in the buffer zone of 250 m from the river and land use was defined as: forest, agriculture and urban area. Measurements of physical parameters (temperature, conductivity, concentration and saturation of 0$_2$), chemical analyses of water (Ca^{2+}, Mg^{2+}, Na^+, K^+, NH_4^+, SO_4^{2-}, NO^{3-}, NO^{2-}, Cl^-), amounts of fine sediments(FS) and particulate organic matter (POC) were carried out on the surface of the river bed and in the hyporheic zones (20-40 cm depth). Biofilm activity was estimated by measuring intensity of electron transport system activity (ETSA) and flurescein diacetate hydrolysis (FDA) in both river zones. Biomass was assessed by using Lowry method to assess protein amount. Results showed significantly different biofilm biomasses and activity between the hyporheic and benthic sediments (Mann Whitney U-test, $p<0.05$). Preliminary results on land use and biofilm biomass/activity relationships showed less obvious linkage. Nevertheless, the obtained results suggest that measurements of the biofilm activity and biomass could be a good indicator of environmental condition. They highlight

the importance of biofilm role in the riverine ecosystems and could be used as a good proxy for the assessment of environmental conditions there.

20-P　The environmental effects of a millennium of mining, metallurgy and land use in Central Sweden: a landscape perspective.　*Erik Myrstener, Christian Bigler, Carsten Meyer-Jacob, Johan Rydberg, Richard Bindler*

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Wherever we turn our eyes, the European landscape has been affected by humans. These large-scale changes are generally considered a modern phenomenon, but human impacts on the environment often have an earlier history. Scandinavia is often perceived as a historically remote landscape, where pre-industrial impacts on the environment are considered minor. However, the rise of Sweden as a nation has its roots in the Middle Ages and the exploitation of its natural resources – namely the extensive ore deposits of the Bergslagen region combined with its wood resources and waterpower to fuel the metal production. Hundreds of blast furnaces and thousands of mines have been registered across this landscape, and in addition to these activities there was also water regulation, charcoal kilning and settlement – including cultivation and peripheral land uses such as forest grazing and haymaking on mires. Together these activities led to diffuse metal pollution, changes in hydrology and alterations of forest and wetland ecosystems. Here we present paleolimnological data from eight lakes connected to two sites of medieval iron production to study the natural ecosystem dynamics before a discernible human impact (i.e. the background) and how they were affected by this complex of activities. We focus on the low-intensive but spatially more widespread impacts of the associated activities rather than direct impacts of mining and smelting.

We present data on pollen and diatom assemblages, reconstructed lake-water phosphorus (LW-TP), sediment biogenic silica (BSi; measured with Fourier-transform infrared spectroscopy), lake-water total organic carbon (LW-TOC; inferred from visible–near infrared spectra) and sediment geochemistry analysed using loss-on-ignition and wavelength-dispersive x-ray fluorescence spectroscopy.

Our results indicate that background conditions ended more than two millennia ago. Already by ca. 300 BC the studied lake records show long-range lead pollution from Roman metallurgy and by ca. AD 300 the pollen composition shows an increase in plants associated with agriculture (e.g. Poaceae and *Plantago lanceolata*). These activities show no significant impact on terrestrial or aquatic ecosystems, however. It was first with more permanent settlement, expansion of agriculture and establishment of metallurgy occurring from ca. AD 1200 that human impacts became pervasive. Agricultural activities are reflected by the presence and gradual increase of cultivated plants (e.g. *Secale cereale*), and changes in forest composition – initially as an increase in successional species (e.g. *Betula*) and eventually as a decrease in total arboreal pollen. This in turn influences water quality and the trophic status of the lakes, as evidenced by increasing LW-TP and decreasing LW-TOC and BSi. It is also reflected in changes within the diatom assemblage as seen in a gradual decrease of epipelic diatoms and increases in planktonic and tychoplanktonic species.

20-P　Constructed wetlands for agricultural runoff remediation – annual net phosphorous retention.

Anne Marie Haws [1] - *Helene Heimdal Hill* [1] - *Espen Enge* [1] - *Åge Molversmyr* [2] - *Roald Kommedal* [1]

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Use of constructed wetlands is an established technique for reduction of eutrophication potential from diffuse agricultural runoff. Intense agriculture in the Jæren region of southwest Norway, has caused gradual eutrophication of natural water systems over decades, and constructed wetland remediation has been a major mitigation strategy. Despite the extent of construction (more than 100 wetlands established in the Jæren region) limited knowledge on their net effect has been reported. In this work we report annual phosphorous mass balance budget over an established (22 years of operation) constructed wetland receiving diffuse runoff. Continuous monitoring of hydraulic loading and composite flow proportional samples were used for net mass-balance analysis of annual phosphorous retention. The overall annual total phosphorus retention was found to be 82 $g/m^2 \cdot y$ which amount to an annual removal efficiency of 23 %. For dissolved total phosphorous and soluble reactive phosphorous the annual retention was 10 and 4 $g/m^2 \cdot y$, respectively; representing 12 % and 18 % removal efficiency respectively. Results show net positive retention during low and intermediate hydraulic loading, however, significant amounts of retained phosphorous is lost through storm

water event washouts. This effect is mainly related to sediment and solids material washouts, and observed total suspended solids increased from less than 3 mg/l during low/intermediate hydraulic loading, to more than 300 mg/l during storm events. Surface hydraulic loading rates during these events increased from dry water levels of 0.5 to >30 l/m$^2\cdot$min during heavy rainfall, giving a storm water hydraulic loading factor of 60. Particle washout was strongly correlated to total phosphorous loss without any concurrent effect on dissolved phosphorous fractions. Hence, effective net phosphorous retention in constructed wetland depends on hydraulic loading and future design and operations must take peak water flow rates into account to avoid particle washout situations.

20-P   Assessing water quality in streams on a watershed basis using a relationship between benthos and riparian land use.   *Ronald Griffiths*

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Efforts to incorporate stream water quality information into land-use planning or lake management processes have been hampered because it is not readily available in a convenient format (i.e. maps). Fortunately, the close interdependency between water quality and adjacent riparian land-use allows for a GIS solution. Multi-spectral satellite or aerial imagery can be used to quantify woody vegetation density within 100m of streams (i.e. riparian wildlands) over large areas. Since BioMAP, a water quality index based on benthic macroinvertebrates, is directly related to riparian wildland density for southern Ontario streams (bankfull width <16m), it can be used to estimate water quality conditions along streams, as unimpaired (BioMAP score >12) or impaired (BioMAP score < 10), thus mapping water quality throughout a watershed based in the density of riparian wildlands. Unimpaired water quality conditions were found to occur in 25% of 32,409 km of streams draining to Lake Erie, and 30% of the 17,745 km of streams draining to Lake Huron. Unimpaired water quality conditions increased in Lake Huron watersheds in a northerly direction, from the Ausable River with 21.1% unimpaired stream km to the Saugeen River with 40.6%. It was further noted that streams with impaired water quality had greater sediment phosphorus concentrations, suggesting greater nutrient impacts on nearshore environments of the receiving lake as water quality impairment increases within the watershed. Percent stream km with unimpaired water quality provides a robust Environmental Performance Measure that summarize water quality conditions at a watershed scale without reference to any particular location. Meanwhile, the observed distribution of water quality throughout the watershed provides insight on riparian areas that are over developed or require restoration.

20-P   From clear blue to opaque green: the mysterious and unintended anthropogenic transformation of the Montebello Lakes, Chiapas.   *Javier Alcocer, Luis A. Oseguera*

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The "Lagunas de Montebello" National Park is located in the state of Chiapas, southern Mexico. It was declared a protected natural area on 1959 and acknowledged as Ramsar Convention site number 1325 on 2003. The karstic landscape extends to Guatemala and holds numerous solution lakes, more than 50 just in Mexico. However, several changes have occurred in some lakes since 2003, such as a modification in the color of the water from crystal clear to yellowish-green and the occurrence of a yellowish-green supernatant, fetid odors, and fish mortality. These changes caused confusion among residents and authorities that demand to find out the reason of these changes that had impacted social, touristic and economically the region. In spite of the name of the national park and Ramsar site ("Lagunas de Montebello"), the limnological characteristics of the lakes are essentially unknown. To solve the "mystery", we carried out a sampling program to evaluate the concentration of chlorophyll-a as a proxy of the phytoplankton biomass in a sample of 18 lakes including shallow and deep and small and large of both categories: pristine (blue) and impacted (green) lakes. Basic characterization of limnological variables was carried out with a Hydrolab DS5 water quality multiprobe and a Biospherical PNF-300 system. Chlorophyll-a was evaluated with a TD-10AU Turner Design fluorometer (detection limit 0.025 µg L-1) under EPA method 445.0 (Arar & Collins 1997). Pristine lakes are transparent with euphotic zones of 30-40 m in average, while the impacted ones are turbid with euphotic zones averaging 1.5-2 m. Shallow lakes turn out to be polymictic while the deep ones warm-monomictic. Pristine lakes showed a deep thermocline while the impacted lakes displayed a very shallow thermocline. Pristine shallow lakes show dissolved oxygen at the bottom all the time while the impacted shallow ones became anoxic. Pristine and impacted deep lakes became anoxic during the stratification; however, the anoxic layer in pristine lakes started deeper than the impacted

ones that became anoxic very close to the surface. Chlorophyll-a concentrations resulted quite low in pristine lakes averaging < 1 µg L-1 (ultraoligo- to oligotrophic) in contrast with the impacted lakes where chlorophyll-a concentrations averaged almost 50 µg L-1 (eu- to hypereutrophic). Pristine lakes show characteristic deep chlorophyll maxima, while impacted lakes show surface-subsurface chlorophyll maxima. The changes detected in the impacted lakes are associated to higher chlorophyll-a concentrations, higher biogenic turbidity, and prolonged anoxia. Larger loads of nutrients as well as organic matter through untreated sewage, fertilizers, and soil erosion associated to intensified agriculture, population increase, deforestation, and larger touristic activities, surely explain the observed changes in the lakes.

20-P   Impact of land use in catchments on disappearance and overgrowth of lakes during the last 80 years in central-western Poland.   *Krzysztof Achtenberg , Agnieszka Lawniczak*

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Changes of the area of lakes are a natural process that occurs in nature. They depend mainly on the lake morphometric parameters, water balance, and natural lake eutrophication process. Intensification of human pressure results in accelerating lake eutrophication and disturbances of the natural processes occurring in water bodies. This primarily concerns land reclamation, construction of hydro-technical structures, industrial water use and climate change.

The activities in lake catchments have a significant impact on water quality. Beside wastewater discharges, non-point sources are the major sources of water pollution, of which agriculture is the most important: intensification of agriculture, particularly fertilization level, type and timing of fertilizer application, the method of their application to the soil, method of cultivation and agronomic practices, and the level of animal production. Catchment land use also has a crucial impact on the intensity and magnitude of nutrient leaching, especially nitrogen.

The aim of the study was to analyse disappearance and overgrowth of lakes during the last 80 years (1930-2010) in the different types of land use in catchments. Changes of lake surfaces and littoral zones were evaluated based on cartographic maps from 1930 and orthophotomaps from 2010. Additionally, aerial photographs and vector-to-date spatial databases were used. In total, 27 lakes smaller than 150 ha were analysed, within agricultural (arable fields cover more than 50% of the catchment area) and forested (forests cover more than 50% of the catchment area) sites. The studied lakes are located in central-western Poland, characterised by the highest level of agricultural production.

The results showed a strong correlation between the average depth of the lakes and the rates of their disappearance and overgrowth. Lakes with an average depth of 3.5 m were characterized by a decay rate of 18% during 80 years. The indicator of lake overgrowth in that group, expressed as the proportion of the littoral zone to the surface of the lake, was 26.21. In lakes with a depth of over 3.5 m the average rate of overgrowth was twice as low, at 13.94; the rate of disappearance was 13%.

In agricultural catchments the rate of lake overgrowth was twice as low as in the forested catchment areas: 0.04 ha/year and 0.08 ha/year, respectively. Similarly, the rate of lake disappearance for water bodies located in the agricultural areas was twice as low as in the forested lands: 7% and 16%, respectively. Moreover, RDA analysis showed a stronger correlation between morphometric parameters of the lake and the degree of its overgrowth than the structure of land use in the catchment.

20-P   Sustaining the new york city water supply: two decades of water quality improvement under intensive watershed protection. *Lorraine Janus*

New York City Department of Environmental Protection (NYCDEP), Government, New York, United States

New York City's reservoirs provide over one billion gallons of drinking water each day to nine million consumers. This water comes from the Catskill, Delaware, and Croton watersheds that extend more than 125 miles from the City, and includes 19 reservoirs in nearly 2,000 square miles of watershed. The City has invested more than $1.5 billion in watershed protection programs to maintain a waiver from filtration for the Catskill and Delaware Systems, and this supply remains one of five large unfiltered supplies in the US. Storms, seasonal changes, and watershed activities drive water quality variation. More than two decades of data for the Catskill and Delaware reservoirs were plotted on the standard regression lines developed by the 'Eutrophication Programme' of the Organization for Economic Cooperation and Development (OECD). This context provides a view of the importance of the suite of watershed protection

programs, the impacts of storm events, and the direction of trophic evolution as these protection programs, begun in the 1990s, mature. The investment in watershed protection has provided significant improvements in water quality.

20-P   Aspects of *Argulus foliaceus* (crustacea: branchiura) freshwater parasite presence in the Preajba Valley lakes (Dolj, Romania). *Goga Ionelia Claudia*

The Oltenia Museum Craiova, Nature Sciences, Museum, Craiova, Romania

Argulosis the most common shellfish, specific to many freshwater fish species in the world. The Argulidae family with Argulus genus comprises about 150 species currently known, which parasitize the fish gills and skin. At the same time they are hematophagous crustaceans having the body well adapted for the parasitic life. This study is based on the material collected from sporadic seasonal fishing conducted in the ten reservoirs located along the Preajba river, between spring and autumn 2009. After the examination of the 42 specimens of the caught fish representing 10 species, the parasite was reported just at two species: *Perca fluviatilis* L. 1758 and *Cyprinus carpio* L. 1758, having as causative agent the *Argulus foliaceus* L. 1758 crustacean. In terms of location, the ectoparasite has an increased intensity with over ten individuals located in the caudal peduncle, in the eyes and fins. The samples with parasites were examined with the Olympus BX 43 optical microscope as a fresh preparation on slide - both ventral and dorsal slides, examining the abdominal lobes (the division grade and their appearance) to determine the species. The parasite acts on the host causing injuries to the mouth cavity of the brachial epithelium, and causing the destruction of the skin surface mucous layer, determining small ulcers necrosis.The proposed measures to control the argulosis in the Preajba Valley lakes are the following: to limit the water penetration from a lake to another through the drainage basins in order to avoid introducing the infected fish and the important role of the spring viremia of carp virus which must be taken into account.

21. BIOGENIC GAS FLUXES IN RESERVOIRS: FROM PROCESSES TO EMISSION OF GREENHOUSE GASES

21-O   The global GHG footprint of reservoirs.   *Yves Prairie [1] - Cynthia Soued [1] - Sara Mercier-Blais [1] - Roy Nahas [1] - Atle Harby [2] - Jukka Alm [3]*

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Concerns over the emission of potent greenhouse gases from reservoir have been a subject of debate for nearly two decades. While individual system can be produce large amounts of GHG depending on both regional and local characteristics, there is currently no general models that can integrate the multiple factors to predict GHG emissions. As a consequence, there is little consensus on the magnitude of the GHG footprint at the global scale and current estimates are largely derived from the extrapolation of average gross emissions values from a limited number of reservoirs. We have developed predictive models of both CO_2 and CH_4 emissions from literature data and globally available geographic databases on land cover and climatic variables to quantify the net emissions attributable to the reservoirs and have applied the models to a set of about 7000 reservoirs worldwide. Upscaling our analysis to world reservoirs (about 260,000 km^2) suggest that net global emissions are lower that previously reported, both in terms of methane (<3 Tg CH_4) and carbon dioxide (≈25 Tg CO_2).

21-O   Benthic dissolved organic carbon in drinking water reservoirs controlled by iron.   *Tallent Dadi [1] - Katrin Wendt-Potthoff [1] - Kurt Friese [1] - Jörg Tittel [1] - Andreas Musolff [2] - Matthias Koschorreck [1]*

Ufz - Helmholtz Centre For Environmental Research, Dept. Lake Research, Magdeburg, Germany [1] - Ufz - Helmholtz Centre For Environmental Research, Dept. Hydrogeology, Leipzig, Germany [2]

Increasing concentrations of dissolved organic carbon (DOC) pose problems for drinking water production from reservoirs due to increased water treatment costs to remove the DOC and potential formation of toxic, carcinogenic disinfection by-products like trihalomethanes. The DOC concentration in reservoirs is a result of loading from the catchment as well as reservoir internal processes. We investigated the effect of sediment-water interactions on the DOC in the water of three German drinking water reservoirs by sediment core incubations under different temperature and redox conditions.

Depending on environmental conditions, the sediment surface was either a source or sink of DOC. Redox conditons were the primary regulator, since DOC uptake by the sediment was only observed under oxic conditions. The benthic DOC flux showed a strong positive correlation to the fluxes of iron and phosphorus, suggesting that they were controlled by the same mechanism. Artificially switching sediment cores from oxic to anoxic conditions turned the sediment from a DOC sink into a source. This was probably caused by a reductive dissolution of ferric iron minerals and mobilization of adsorbed organic carbon.

A strong correlation between DOC flux and temperature showed, that DOC mobilisation in the sediment was influenced by microbial activity. Benthic DOC exchange was quantitatively of minor importantance for the reservoirs' DOC budget, but represented a significant process in the benthic carbon cycle. Higher temperatures caused by future climate change as well as more reducing conditions in the hypolimnion will stimulate benthic DOC release.

We conclude that benthic DOC is primarily controlled by redox dependent adsorption to iron minerals. The analysis of monitoring data from reservoir inflows suggests that similar mechanisms are responsible for DOC mobilisation from catchments.

21-O   The fate of soil carbon 80 years after reservoir filling: potential consequences.   *Jim Félix-Faure [1] - Etienne Dambrine [1] - Christian Walter [2] - Alexandre Gouvain [2] - Jean-Noël Avrillier [1] - Stéphane Descloux [3] - Vincent Chanudet [3]*

Centre Alpin de Recherche sur les Réseaux Trophiques et les Écosystèmes Limniques, National Institut of Agricultural Research/ University of Savoie Mont Blanc, Le Bourget Du Lac, France [1] - Sol Agro et Hydrosystème Spatialisation, National Institut of Agricultural Research/agrocampus, Rennes, France [2] - Electricity of France (EDF), Centre D'ingénierie Hydraulique, Le Bourget du Lac, France [3]

About 500 dams creating large water reservoirs have been built in France since 100 years. Compared to natural lakes, the ecology and carbon budget of these water bodies are influenced by the submerged soils and vegetation, as well as by the artificial management of the water level. The fate of soil carbon 80 years after dam establishment has been studied at the Guerlédan reservoir, Central Brittany. After the filling by water in the 1930, the valley soils evolved in relation to their position in the landscape and that of the lowest water level in the reservoir. Along 3 toposequences on sandstone, schist and granite, with different land use (forest and prairie), we have measured the variations of soil carbon stores after submersion. From the uppest water level to the former river bed, and compared to adjacent natural spodosols and cambisols, we distinguished 1 eroded mineral soils enriched in sand and rock fragments in the tidal zone, 2 truncated soils in the lower part of the tidal zone, 3 soils covered by sediments on lower slopes and valley bottom. These soils have lost, either by erosion or by mineralisation, a large part of their original C content. At the reservoir scale, our budgets suggest a strong and long lasting influence of eroded and submerged soils on the carbon budget of the reservoir. These fluxes are discussed in relation to their potential greenhouse effect.

21-O   Greenhouse gas emissions from two Scottish reservoir catchments.   *Roseanne McDonald [1] - Fraser Leith [2] - Ute Skiba [2] - Michael Billett [3] - Christopher Evans [4] - Susan Waldron [5] - Kerry Dinsmore [2] - Zoe Frogbrook [6]*

Centre For Ecology & Hydrology (ceh), University of Stirling, Edinburgh, United Kingdom [1] - Centre For Ecology & Hydrology (ceh), N/a, Edinburgh, United Kingdom [2] - Biological And Environmental Sciences, University of Stirling, Stirling, United Kingdom [3] - Centre For Ecology & Hydrology (ceh), N/a, Bangor, United Kingdom [4] - School of Geographical And Earth Sciences, University of Glasgow, Glasgow, United Kingdom [5] - Scottish Water, N/a, Edinburgh, United Kingdom [6]

Inland waters play an important role in the transport, biochemical transformation, loss and storage of carbon (C) on its way from the land to the ocean. Human alteration of the aquatic landscape, for example through reservoir creation, will also influence carbon balances. Reservoirs are a conduit for terrestrial C flows as well as a potential source of greenhouse gases (GHGs) to the atmosphere. Typical carbon sources found in reservoirs are the initial submersion of soil and subsequent decay of plant materials, continual vegetation decay from fluctuating water levels, and organic matter input from catchment runoff.

A disconnect between the study of stream and lake C dynamics inhibits an understanding of their significance at national and global scales, and although a body of knowledge exists on large surface area lakes and reservoirs, recent studies suggest that the small spatial scale of streams belies their significant influence on the carbon dynamics. Quantifying C fluxes for an entire aquatic continuum, i.e. the connected network of streams and reservoirs within a catchment, is difficult and rarely attempted, but such an integrated approach appears increasingly important.

This research examines aquatic pathways in two distinctive Scottish reservoir catchments, Black Esk (forested) and Baddinsgill (peatland), and their role in GHG emissions and the C cycle. We report on 1 year (to date) of carbon dioxide, methane and nitrous oxide concentrations measured at fortnightly intervals using the headspace method, fluvial fluxes of dissolved inorganic carbon (DIC) and dissolved organic carbon (DOC), and other characterising measurements taken from inflows, outflows and body of the reservoirs. Preliminary results reinforce the need to consider the connectivity of an aquatic system to capture a comprehensive picture of the carbon cycle. Future work will continue this investigation, and incorporate high-frequency sensor data to examine carbon dioxide evasion at larger spatial scales.

21-O   Greenhouse gas emissions from a French old hydropower reservoir.   *Vincent Chanudet [1] - Dominique Serça [2] - Frédéric Guérin [3] - Stéphane Descloux [4]*

Hydro Engineering Centre, Electricité de France, Le Bourget Du Lac, France [1] - Laboratoire d'aérologie, Univeristé Paul Sabatier, Toulouse, France [2] - Laboratoire Géoscience de l'Environnement (GET) - Ird, Université Paul Sabatier, Toulouse, France [3] - Hydro Engineering Centre, Electricté de France, Le Bourget du Lac, France [4]

Biogenic gaseous emissions from reservoirs are now a well known phenomenon, especially in tropical (South America, Asia, Africa) areas were many studies have been done. Emissions in boreal reservoirs have also been studied. Until recent studies, temperate reservoirs have been much less studied. In tropical reservoirs, higher carbon stocks (dense forest for instance) and higher temperatures are known to boost the ecological processes responsible for GHG production. The consequence is that there is a lack of data in temperate countries. For the first time to our knowledge, a temperate reservoir has been studied over a full year with monthly sampling to assess seasonal variation. This was done with this study in the Eguzon Reservoir. This old and eutrophic hydropower reservoir (204 m asl, 312 ha, 57.2 Mm^3) is located in the central part of France. Concentrations in organic and inorganic carbon species have been measured in the incoming rivers, in the reservoir and in the released water (turbines and environmental discharge). The main greenhouse gases emission pathways have been measured: diffusion at the reservoir surface, bubbling, degassing and downstream emissions. Results show a spatial and seasonal variability of GHG concentrations and emissions. The relative contribution of GHGs also changed along the year. These evolutions were correlated to environmental parameters (temperature, oxygen, discharges…): the seasonal thermal stratification and the inflow changes play key roles in the GHG dynamics in the reservoir. At the annual scale the carbon budget of the reservoir is equilibrated with about 4000 tC/yr entering and leaving the reservoir. The fraction of organic carbon as compared to the total carbon fluxes was similar in the incoming rivers and in the released water (46%). The main GHG pathway was diffusion on the reservoir, the contribution of bubbling and downstream diffusion being balanced.

21-O   Modelling methane dynamics from a seasonally ice-covered boreal reservoir.   *Weifeng Wang, Laura Lyon, Nigel Roulet*

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Flooding terrestrial ecosystems to form a hydroelectric reservoir submerges large amounts of terrestrial organic carbon stored in terrestrial plants and soils. Environmental conditions changing from aerobic to anaerobic could enhance methane emissions from the reservoir surface. In order to quantify the response of biogeochemical processes to such a land use change, a one-dimensional process-based reservoir biogeochemical model was developed. We simulated complex physical and biogeochemical processes of methane production, oxidation, transport, and emissions in the sediment and water column. The model was calibrated and tested against observational data from a large boreal hydroelectric reservoir, northern Quebec, Canada. The modelled methane fluxes across air-water interface were consistent with measurements. The simulated mean partial pressure of methane agreed well with observations from the generating station in the dam. The seasonal variability of methane emissions was primarily controlled by the reservoir thermal dynamic (e.g., ice-cover timing and water mixing) that is a response to climate. The decomposition of flooded terrestrial organic carbon in the sediment stimulated methane emissions of the reservoir ecosystem in the first 5-yrs after the reservoir creation. This study demonstrated that the sinking organic carbon from the water column would become the major source of substrate for methane production when the reservoir developed to be a "natural" lake. We conclude that flooding changes the biogeochemical cycles and, moreover, triggers methane emissions from the newly created aquatic ecosystem.

21-O   Emissions of greenhouse gases (CO_2 and CH_4) from the Itaparica Reservoir (Pernambuco, Brazil).   *Maricela Rodriguez [1] - Peter Casper [1] - Günter Günkel [2]*

Leibniz-institute of Freshwater Ecology And Inland Fisheries, Dept. Experimental Limnology, Berlin, Germany [1] - Berlin University of Technology, Berlin, Germany [2]

Tropical reservoirs have been found to be important sources of greenhouse gases to the atmosphere, however disregarding of spatial-temporal variability have lead to uncertainties on emission rates on the regional and global scale. Carbon dioxide (CO_2) and methane (CH_4) emissionswere measuredin the Itaparica reservoir, located in a semiarid region in Northeast Brazil.Emissions through diffusion, ebullition and degassing (turbine passage), were measured during four campaigns within the zones (i) littoral (less than 5m depth),(ii) the central part of a selected bay,(iii) along the riverine zone and (iv) before and after the turbine passage. Diffusive and ebullitive emissions were estimated using the Thin Boundary Layerconcept and inverted funnels,respectively; degassing losses wererevealedby comparing concentrations before and after turbine passage. Mean diffusive emissions were estimated to 3.3± 3.8 g m^{-2} d^{-1} for CO_2 and 0.14±0.15 g m^{-2} d^{-1}for CH_4.Diffusive CH_4 emission and its variability were higher in the littoral zone. Ebullition was limited to occur

up to 3m water depth, mean daily fluxes for CH_4 and CO_2were0.3± 0.7and 0.6± 1.2 mg m^{-2},respectively. Due to well mixedand oxygenated conditions of the water column in this reservoir, CH_4can be rapidly oxidized by methanotrophic microbes at the oxic/anoxic interface, thus concentrations of CH_4 along the water column were low.Low methane content in the waterbefore the dam inlet resulted in no measurable losses of this gas during turbine passage.Conversely, accumulation of CO_2 in bottom waters before the dam results in gas losses which ranged between 44 to 70 t d^{-1}, this CO_2 accumulationmay result from higher microbial activities and could be effected by bottom water withdrawal to the turbines.Mean emissions values were scaled to the surface area covered by the related zone and summed up to calculate total reservoir emissions, yearly emission are about 0.85 ± 0.83 Tg CO_2and1.2 x 10^{-5}±0.03 Tg CH_4.Diffusion is responsible for 97% of CO_2emissionswhilst $CH_4$is released mainly through ebullition(58%).Hydrological processes and morphology of the reservoir including water depth and water level changes are main factors influencing GHG emissions. Reservoir bays may act as GHG release hotspots due to eutrophication processes occurring locally, leading to oxygen depletion and higher availability oforganic substances as source for methane production.

21-O   Greenhouse gas emission from Amazon reservoirs. *John Melack* [1] *- Alexandre Kemenes* [2] *- Bruce Forsberg* [3] *- Joao Amaral* [3] *- Sally MacIntyre* [1]

Earth Research Institute, University of California, Santa Barbara, United States [1] *- Embrapa Mid-north, Teresina, Brazil* [2] *- Instituto Nacional de Pesquisas da Amazonia, Manaus, Brazil* [3]

Carbon dioxide and methane, generated in reservoirs, are released within the reservoirs and downstream of dams. To improve understanding of diffusive releases from tropical reservoirs we measured turbulence as rate of dissipation of turbulent kinetic energy (TKE) based on microstructure profiling in Balbina Reservoir, located in the central Amazon basin. Comparison of these measurements with meteorological measurements and thermal profiles indicate high dissipation rates under diel heating. Gas exchange coefficients calculated from measurements with floating chambers are similar to those based on the dissipation rates of TKE, and are higher than previous estimates. In Balbina Reservoir fluxes of methane from the reservoir surface and downstream are about equal. Fluxes downstream of three additional Amazon hydroelectric reservoirs (Tucuruí, Samuel and Curuá-Una) are also significant. Additional releases along the Tocantins, Jamari and Curuá rivers were measured at downstream sites over a distance of 30 km. Approximately 50 % of the methane and 30 % of the carbon dioxide emitted downstream of the dams were liberated at the turbine outflow. The total downstream emissions are sufficiently large to require consideration in assessments of greenhouse gas emissions from hydroelectric reservoirs.

21-O   Net emissions estimations of greenhouse gases in hydroelectric reservoirs in Brazil. *Marco Aurelio dos Santos[1], Jorge Machado Damazio* [2]*, Josiclea Pereira Rogerio* [1]*, Marcelo Andrade Amorim[1], Alexandre Mollica Medeiros* [2]*, Juliano Souza Abreu* [2]*, Vinicius Layter Xavier* [3]

Energy Planning Program, Ufrj, Rio De Janeiro, Brazil [1] *- Cepel/Eletrobras, Eletrobras, Rio De Janeiro, Brazil* [2] *- Department Of Statistics, Uerj, Rio De Janeiro, Brazil* [3]

Here we presents the results of the greenhouse gases emissions and removals (CH_4, CO_2 and N_2O) obtained from measurements performed on 32 field campaigns carried out from March 2011 to January 2013 at several Brazilian hydropower plants. It also provides the net emission calculation which was discounted estimates of balance emissions and removals of the flooded region in the period before the filling of the reservoirs studied. Measurements campaigns were made at hydropower plants of Balbina, Tucuruí, Xingó, Serra da Mesa, Funil, Itaipu, Segredo and Três Marias that given geographic location may be representative of the different biomes and characterize different Brazilian climatic regimes. To calculate the balance of GHG emissions and removals were used ebullitive and diffusive emissions, and permanent sedimentation rates at the body of the reservoirs, downstream diffusive emissions and emissions of degassing. The results of the balances showed the importance of CO_2-eq of the removal of permanent sedimentation process, since the values found in Xingó removals were higher than emissions. The results of net emissions per unit of energy produced were inferior emissions by thermal power plants. The only exception was the use of Balbina which are associated with an extensive flooded area and capacity of no significant generation.

21-P Nitrous oxide profiles in Lake Hachiro from long-term and daily surveys.   *Shuhei Masuda* [1] -
Takemi Sato [2] *- Shohei Otomo* [1] *- Chikako Maruo* [2] *- Osamu Nishimura* [2]

Department of Civil And Environmental Engineering, National Institute of Technology, Akita College, Akita, Japan [1] *-
Department of Civil And Environmental Engineering, Tohoku University, Sendai, Miyagi, Japan* [2]

Nitrous Oxide (N_2O) is a potent greenhouse gas (GHGs) as well as an ozone layer depleting gas. N_2O is produced in the sediment of rivers through biological nitrification and denitrification, but its characteristics have not been fully investigated. This N_2O production and emission from rivers is called indirect emission. According to the latest guideline for the calculation of GHGs emissions by IPCC, the emission factor (EF) of the indirect emission of N_2O from rivers, 0.0025, might be overestimated, and its range of uncertainty is high. Therefore, further collection of data for N_2O emission from rivers is needed.

Lake Hachiro, which is located in the north east of Japan, is a lake under eutrophication. We surveyed the five main rivers which flow into Lake Hachiro, the mouth of the lake and two drainage canals in the reclaimed land inside the lake. The survey was carried out once a month, from April 2012 to October 2014 with the exception of the winter season (November to March). Additionally, a daily survey was conducted in three rivers in May 2015. Based on these surveys, the relationship between water quality, watershed and N_2O were discussed.

We took water samples from each sampling point using a bucket. T-N, NH_4, NO_2, NO_3, and TOC were analyzed. The stable isotope analysis of $\delta^{15}N$ and $\delta^{18}O$ in NO_3 were also conducted in the 2015 survey. The concentration of DN_2O was analyzed by ECD gas chromatography with the head space method.

The results of the seasonal survey from 2012 to 2014 revealed that the concentration of DN_2O showed the seasonal variation. The DN_2O concentrations were higher from May to July than the other seasons, this is when a lot of water flowed into the rivers and lake from rice fields. The water from rice fields in that season might contain nitrogen fertilizer, so N_2O was produced by biological nitrification and denitrification. The maximum average value of $DN2O$ of all sampling points for each year was 2.20 µg/L in July in 2012 and 3.27 µg/L in May in 2013. In 2014, although the maximum average value of DN_2O was observed in April which was 1.99 µg/L, the second maximum value of DN_2O was 1.86 µg/L in July. The relationship between the DN_2O concentration and water qualities was not clear, but the EF of DN_2O to NO_3 was calculated as 0.0033 DN_2O-N/NO_3-N.

From the daily survey of three rivers in 2015, a daily variation was observed only in one river, the Bafumi river. The averaged DN_2O in the Bafumi river was 0.90 ± 0.41 µgN_2O-N/L (n=13). The DN_2O concentration was higher at night and lower in day. This might be caused by the activation of the denitrification in the sediment of the river due to the decrease of dissolved oxygen. Based on the stable isotope analysis of $\delta^{15}N$ and $\delta^{18}O$ in NO_3, it is believed that the Bafumi river is influenced by domestic wastewater and agricultural water usage, which cause the daily variation of the DN_2O concentration followed by biological nitrification and denitrification

21-P Methane emissions estimation by drawndownd zone of tropical reservoir during drought period, Funil Reservoir, Rio de Janeiro- Brazil.   *Marcelo Amorim, Marco Aurélio Santos*

COPPE / UFRJ, Universidade Federal Do Rio De Janeiro, Rio De Janeiro, Brazil

Between 2014 and 2015 drought period in southeastern Brazil reached worrying levels causing in the region a water crisis. This scenario of extreme drought impacted the water accumulation in hydroelectric reservoirs. This situation of low water level having exposed its drawndown zone in contact with the atmosphere. This sediment deposited over the years in the background and flooded slopes becomes exposed and has a straight contact with the atmosphere. As the sediments of the drawndown zone are exposed, even on vegetation is formed. Studies report that greenhouse gases (GHG) are produced (or consumed) in soils from a result of microbial processes, but this fluxes between the exposed soils and the atmosphere depends heavily on physical factors and characteristics of the sediment.

The purpose of this study was to estimate the fluxes and total emissions of methane by this drawndown zone throughout the reservoir in tropical region like the Funil Reservoir at Rio de Janeiro, Brazil. With the polynomial calculation of volume and area of the reservoir as well as the height of the drawndown zone we reconstitute the exposed area for each sampling period. Soils samples collected along the reservoir and static chambers measurements fluxes are provided in the sediment exposed zone. It was provided three samples periods in the reservoir. These samples were divided into three sets according to the volume of water. Sediment samples were also collected to get values of organic matter (% TOC and C:N ratio), grain size and sediment characteristics were taken.

The total organic carbon content (TOC%) in samples showed low values. The highest value was found in the collection of the intermediate volume setting. This increase can be interpreted perhaps for the arrival of the rains, which provide the input of allochthonous material in the drawdown zone from the watershed. Such low total organic carbon values can be related to the erosion that the drawndown zone undergoes both by exposed weather, wind, water and the percolation waves. The values of C:N ratios were also low, below 4.

In the scenario with the lowest volume of water (9.09% of the operating volume) the estimated value of methane emission was 0,234 t CH_4 km^{-2} dia^{-1}. With the advent of rain, and increased reservoir dimensions found as a result the volume of 40.91% of the operating volume absorption -0.127 t CH_4 km^{-2} dia^{-1} and with 59.09% of the operating volume, the absorption was -0.003 t CH_4 km^{-2} dia^{-1}.

It is observed a variation in accordance with the rainfall and increasing water level of the reservoir. With the arrival of rain, the fact of having more water in the interstitial material sediment, favoring the chemical reactions by bacteria, as well as changes in both organic material and grain size in the collection sites.

22. COMMUNITY LIMNOLOGY: CITIZENS AND COMMUNITIES SUPPORTING FRESHWATER RESEARCH

22-O   Assessing water quality in urban stormwater ponds in Toronto, Ontario with citizen scientists in the freshwater watch program.   *Paul Frost, Andrew Scott*

Department of Biology, Trent University, Peterborough, Canada

FreshWater Watch is a global program funded through EarthWatch that aims to sample urban water bodies around the globe through the efforts of citizen science volunteers. We are contributing to this program in Toronto, Canada with a project on urban stormwater ponds. Our Toronto sampling program aimed to describe spatial and temporal patterns of water quality (i.e., nutrients concentrations) in urban ponds over the open water season (April to November) using citizen science volunteers. To do so, we trained 110 volunteer water samplers over the course of three years to collect data all following the same protocols. These volunteers independently sampled local water bodies and uploaded their data to a central database using a web portal. After three years of sampling, our Toronto project has accumulated 130 sampling events from 26 pond locations. A small number of trained volunteers (<20) participated and accounted for most of water sampling events. Different mechanisms to engage and motivate volunteers including group emails and social media appeared to have little effect on increasing the number of active participants. However, personalized e-mails seemed to motivate the more active participants to sample on a more frequent basis. In terms of sampling results, we found average N and P concentrations in Toronto were lower than those measured at the other global sites, especially in Asia and South America. Overall our project demonstrates both the promise and potential complications in engaging citizen scientists in water quality sampling and the aquatic sciences.

22-O   Spatial–temporal features of eutrophication and its drivers in the Huangpu River systems combining citizen science and land use data.   *Yuchao Zhang [1] - Steven Loiselle [2] - Ronghua Ma [1]*

Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, Nanjing, China [1] - CSGI, University of Siena, Siena, Italy [2]

The Huangpu River, located in the complex hydrological network of China's Taihu Lake basin, is a complex river system with more than 200 tributaries. In recent years, massive land use changes and increased urbanization have led to a growing eutrophication and an overall degradation of the river's water quality, with related risks to the drinking water supply and the economic development of Shanghai. However, there is only limited information to evaluated possible changes to the Huangpu River and its many tributaries, in particular related to the relationship between spatial patterns of land use and temporal variability of water quality.
In the Huangpu tributaries project, teams of citizen scientists have gathered water quality and land use data from key tributaries on a monthly basis. This information was combined with high resolution satellite based estimates of land cover, population density, stream hydrology and meteorological parameters. Clear seasonal variations were evident in all study waterbodies, with a general increase in nutrients (nitrate and phosphate) during months with increased precipitation and an overall reduction in turbidity. More algal blooms were reported, as would be expected, in the summer monsoon season.
Combining data from individual sampling sites with land use data (reported by citizen scientists) and land cover data (from a high resolution GIS) indicated that both information sources provide useful data to explain stream variability. The reported presence of locally observed pollution sources related significantly to measured nutrient concentrations and water color. On the other hand, watershed area and stream order were found to influence phosphate concentrations and the reported presence of algal blooms.
The results of the study indicate that information obtained by trained non-scientists on land use, pollution sources and water quality can provide needed high resolution information in complicated river networks like that of the Huangpu-Taihu basin.

22-O   Citizen scientists monitor algal toxins in Missouri (USA) lakes and build effective partnerships.

Anthony Thorpe, Daniel Obrecht, John R. Jones

School of Natural Resources, University of Missouri, Columbia, Missouri, United States

By successfully partnering with citizen scientists, the University of Missouri (USA) has extended its lake monitoring efforts by more than 50% through the Lakes of Missouri Volunteer Program. The partnership between the university and state environmental regulatory body has enjoyed a 25-year history. The model of citizen collection coupled with laboratory analyses on campus provides quality-assured data, which is used to characterize conditions and track changes in lake water quality. Based on this success, a new monitoring opportunity was approved by the funding agency.

In late summer 2015, citizen scientists and laboratory staff with the University of Missouri, though a combined effort, monitored 92 lakes for microcystin concentration. The proportion of samples with microcystin values greater than 1.0 µg/L was 3 times larger in 2015 (12%) than similar statewide inventories conducted during 2004-2006 (average = 4%). The difference was possibly a consequence of the late-season focus of 2015 collection but may signal in increase in occurrence. Duplicate samples collected by volunteers were independently analyzed at the University of Missouri and by the State of Missouri's Department of Natural Resources. Paired t-test indicates no significant difference between the two labs' results.

Due to their proximity to lakes and social connection with the lake community, citizen scientists are more likely than field staff to encounter and sample a short-lived cyanobacterial bloom. They typically live at and monitor high profile lakes with significant human-water interaction. According to a recent survey of the citizen scientists participating in the program, 57% live lakeside near their sampling location and all participants spend an average of 161 days per year visiting lakes. In the event of a bloom, citizen scientists can respond quickly to collect samples and make observations, with little cost. An inexpensively constructed depth-integrated sampling device ensures standard sampling methods among the volunteers. Smartphones make recording geographic location and taking photographs a simple matter. A citizen scientist trained to monitor for algal toxins (and other measures of water quality) is a valuable resource for the regulatory agency tasked with protecting human and environmental health, for the other lake users, and as a conduit for communication between the agency and lake users.

22-O   Effects of light exposure and long term storage on chlorophyll results.   *Daniel V. Obrecht, John R. Jones*

School of Natural Resources, University of Missouri, Columbia, United States

A benefit of using citizen volunteers who live near lakes to monitor water quality is a lower cost per sample due to reduced travel expenses. If samples must be shipped to a laboratory for processing and analyses after each collection, savings are negated. By having volunteers process water samples at home and store chlorophyll filters frozen in silica desiccant for an extended time, The Lakes of Missouri Volunteer Program minimizes transport cost. This analysis investigates two potential limitations of using volunteers for chlorophyll monitoring: 1) exposure of filters to light during processing, and 2) the effect of long-term storage (>3 months). The effect of light exposure on chlorophyll was tested by processing a single lake sample in the dark (indirect fluorescent light), a lab setting (direct fluorescent light) and outside (direct sunlight). Some filters processed in lab were exposed to direct sunlight for up to 10 minutes before being stored in a light-tight container. The average chlorophyll concentrations for the treatments involving exposure of filters to light ranged from 142.3 to 145.1 µg/L, with no significant differences. The only significant loss of chlorophyll occurred when extracted samples were exposed to sunlight (average 118.9 µg/L). This finding suggest that chlorophyll pigment is not light sensitive until extracted. To test the effects of storage, chlorophyll filters were prepared from five different lake samples. Initial chlorophyll concentrations (2 to 79 µg/L) were determined by analyzing five filters from each lake within 24 hours of sample collection. The remaining filters were divided into two treatments; 1) filters stored frozen with desiccant and 2) filters stored at room temperature with desiccant. Both sets of filters were stored in the dark. Five filters from each lake were randomly selected from each treatment for analysis; 3, 6, 12, 48, 72 and 96 days after processing. Filters stored in the freezer did not show significant loss of chlorophyll relative to initial values in any of the trials, but results indicate freezing may have facilitated extraction. Average chlorophyll concentrations for filters analyzed after 96 days in the freezer were about 4% greater than initial concentrations. In contrast, filters stored at room temperature for 96 days had chlorophyll concentrations that were less than initial values in all five trials, with significant decreases in four trials. The loss of chlorophyll ranged from 0.33 to 4.75 µg/L, with larger losses coming in trials with the highest initial chlorophyll levels. While the onset of chlorophyll loss in the non-frozen filters varied by

trial, the data suggest that storage in desiccant at room temperature for short periods of time may not be detrimental to results. Collectively, these findings indicate that having citizen volunteers perform chlorophyll filtration in their home and store filters long-term in their freezers does not negatively affect results.

22-O   The importance of local scale factors in phytoplankton and nutrient dynamics in urban freshwater ecosystems.   *Steven Loiselle* [1] *- Luis Felipe Velasquez* [2] *- Daniel Ophof* [2] *- Ian Thornhill* [2]

Earthwatch Institute, University of Siena, Oxford, United Kingdom [1] *- Earthwatch Institute, Earthwatch Institute, Oxford, United Kingdom* [2]

Urban freshwater ecosystems are subject to a wide range of potential impacts, often leading to their degradation and loss. Many are small and fragmented with only limited monitoring. As limnologists, we do not have sufficient information to identify the temporal and spatial dynamics of these waterbodies, nor to identify the local and regional scale drivers that lead to their degradation. Such information is sin qua non to finding solutions to their increasingly widespread degradation. One source of additional ecological and geographic data is that acquired by citizen scientists –volunteers with basic training in data collection and ecosystem analysis.

In the present study, we show how trained and supported citizen scientists can provide key data to understand the drivers of eutrophication and ecosystem degradation in urban freshwater ecosystems. We show how high resolution microscale datasets (12,000) gathered by citizen scientists on water quality, land use and pollution sources can be combined with low resolution satellite- based data on land cover and population to help predict the dynamics of water quality and ecosystem conditions. We show clear relationships between eutrophication metrics (phytoplankton density, nutrient concentrations) and potential drivers across a range of environments on five continents. The results indicate that microscale data from trained citizen scientists provides powerful basis to determine the spatial and temporal dynamics of urban freshwater ecosystems. The availability of complementary citizen generated data will grow in importance as the proportion of people living in urban areas increases. Citizen observatories help us meet linked challenges of improving our understanding of aquatic environments and restoring the connection between human populations and their local ecosystem.

22-O   Integrating science and citizen science: the UK lakes portal.   *Philip Taylor* [1] *- Laurence Carvalho* [1] *- Matthew Fry* [2] *- Iain Gunn* [1] *- Filip Kral* [2] *- Biren Rathod* [2] *- David Roy* [2]

Centre For Ecology & Hydrology, Edinburgh, United Kingdom [1] *- Centre For Ecology & Hydrology, Oxford, United Kingdom* [2]

A comprehensive database of standing waters in the UK has been in continual development since 2004, and includes physical, environmental, typographic and chemical data compiled from an extensive set of sources. Novel modelling techniques and derived catchment characteristics have contributed further to the database, but public access and involvement has, until now, been neither available nor utilised. The newly-developed UK Lakes Portal is a freely-accessible online portal for accessing this database, providing a national inventory of the lakes of the UK, their ecology and surrounding environment.

The National Biodiversity Network (NBN) gateway provides access to UK biodiversity information from a wide range of organisations, from national-scale projects down to more local initiatives. As such, it brings together a wealth of observations from volunteer recorders to increase our knowledge and improve our science. Most citizen involvement to date typically focusses on targeted events or applications aimed at specific species groups (e.g. BioBlitz, Mammal Tracker, iRecord Ladybirds), rather than a landscape or ecosystem approach.

The UK Lakes Portal has been developed to integrate with data from the NBN gateway, creating an innovative platform for freshwater science, recording and knowledge exchange. Each lake in the UK (44,000+) now has a dedicated page with integrated biodiversity data. A new classification of freshwater species has been developed to filter the data, and facilities created to allows new species observations to be recorded at each site using the Biological Record Centre's iRecord system, including the reporting of non-native species.

Additionally, the concurrent development of two apps – FishCatch and AlgalBlooms – will target community involvement in data-poor areas of research. To further improve ecological analysis at a landscape scale, freshwater biodiversity recording events have been organised with identification experts and interested members of the public to

document the species present in, and around, lakes. These events will be promoted to raise the profile of the UK Lakes Portal and generate new data from freshwater communities that are often poorly represented in species records from citizen science.

22-O   Land-use impacts upon turbidity within streams in the Americas are effectively recorded by citizen science as well as remotely sensed data.   *Ian Thornhill* [1] - *Eleonore Heasley* [1] - *Davi Gasparini Fernandes Cunha* [2] - *Loiselle Steven* [1]

Earthwatch Institute, Oxford, United Kingdom [1] - *Departamento De Hidraulica E Saneamento, Universidade se Sao Paulo, Sao Paulo, Brazil* [2]

High levels of turbidity influence important ecosystem processes such as photosynthesis and predator-prey relationships. Increased suspended sediment load can also be a direct cause of fish and invertebrate mortality, particularly at egg and larval stages. Suspended sediment is sourced from catchment soils which are eroded during precipitation events and transported to the river via run-off. More naturalised catchments increase the opportunity for interception of run-off through vegetation growth. On the contrary, human activities such as urbanisation or deforestation are likely to reduce the catchments ability to buffer impacts to the river as the proportion of naturalised land-cover decreases.

Contextual data relating to the local physical environment were collected alongside standardised measurements of turbidity by trained citizen scientists across six North and South American cities between April 2013 and January 2016. For both contextual and remotely sensed catchment land-use data, turbidity increased along with the proportion of built space (e.g. residential) whilst lower levels were associated with grass and shrub land. When compared to remotely sensed land-cover data, locally collected land-use information was most indicative for lower order stream samples. The strength of the relationship between local land-use information and turbidity reduced, though remained significant, relative to catchment scale data as stream order increased.

This research highlights the valuable contribution citizen science can make to our understanding of river dynamics and adds weight to the need consider the impact of surrounding land-use upon water quality.

22-O   Nutrients concentration gradient and urbanisation: are they reflected in the structure community of invertebrates in streams of Argentina?   *Luciana Rocha*

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There is a growing necessity to preserve water quality, as an ecosystem service of aquatic environments, therefore better understand the nature of relationships between environmental stressors and freshwater communities allows meaningful action to take place against the impacts of anthropogenic pressure. Considering excess nutrients as a risk to streams and rivers health, we explore the relationship between concentrations of dissolved phosphate (PO_4) and nitrate (NO_3), urban land use proportion and population density. We analyze the structural response of invertebrates community in a nutrients concentration gradient from the results. The study was conducted in 22 streams with different intensity of urban land use in the "Pampa Ondulada" (Buenos Aires, Argentina). Environmental attributes were recorded between August 2013 and November 2015 by 123 trained citizens as part of the FreshWater Watch (FWW) programme that specified pollution sources near to sampling sites and measured $P-PO_4$ and $N-NO_3$ concentrations. A total of 279 datasets were collected using a consistent methodology and uploaded on to an online database available for the public. The same parameters and epibenthic invertebrates multihabitat samples were collected four times in that period (spring and summer) by professional staff. Cumulative Frequency method (FCT graphs) was used to explore community changes in response to an increase NO_3 and PO_4 concentration. No strong relationship was observed for regressions with phosphate concentrations and population density (adjusted R^2 of 0.09) or proportion of urban land use, whereas strong relationship was obtained for nitrate concentrations with proportion of urban use (adjusted R^2 of 0.62). Likewise, high correlations ($r>0.6$) between NO_3 gradient and population density were observed and with the number of local pollution sources, in particular with urban/road and residential discharges. FCT graphs showed that in a phosphate gradient, there are taxa adapted to low concentrations as   Oligochaeta, Ephemeroptera, Chironomidae and Mollusca; Odonata and Decapoda tolerate low to medium levels and Nematoda high levels, showing the transition area between different attraction dominion to a 0.1 mg/L $P-PO_4$. In contrast, in a nitrate gradient, the invertebrates community in these urban

streams expressed to be adapted to mid and high concentrations (threshold 2.94 mg/l N-NO$_3$). Results allowed analyzing relationships between urban occupation and nutrient concentrations in streams of "Pampa Ondulada", likewise to detect changes in invertebrates community associated with a gradient of phosphates in particular. We emphasize the importance of the information provided by trained citizen scientists that facilitated to identify the conditions of local river systems and to improve our understanding about potential drivers of changes in ecosystems.

22-O   In the eye of the beholder: monitoring water quality of Montreal shoreline parks through citizen science.   *Christiane Hudon, David Lévesque, Antonella Cattaneo*

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St. Lawrence River water quality at 28 public shoreline parks around the Montreal Island was characterized through the Earthwatch water program. This program involved training groups of about 12 HSBC Bank employees by Université de Montréal over one-day sessions held in spring and fall of each year. Shoreline sampling yielded a total of 170 data points over the study period (May 2013 to November 2015). Water turbidity, nitrate and phosphate concentrations were measured with a field kit. Moreover, the thickness and type of vegetation accumulated on the shoreline, and the relative abundance of different types of beach refuse were assessed. Despite the simplicity of the approach, results provide 1) an overview of the water quality of the St. Lawrence River around the island of Montreal, 2) an estimation of the quantity and types of aquatic plants and filamentous algae washed up on beaches and 3) novel insights on the distribution of the nuisance cyanobacterium *Lyngbya wollei*. By combining water and vegetation data with fecal coliform counts gathered by the city of Montreal, we could provide an assessment of shoreline condition. Overall, half of the sites were classified as "good", characterized by sound water quality and low deposition of vegetation on shore. *Lyngbya wollei* was found at 57% of the sites, revealing a more frequent occurrence than initially anticipated. The amount and type of beach refuse recorded in each park was used to evaluate its utilisation for different recreational activities (smoking, picnicking and fishing). Wind exposure and meteorological events explained a significant fraction of variability among sites and dates. This information about status and utilization of the parks will be useful for the municipalities in planning and managing their vocation.

22-P   Nutritional service of the middle Paraná River, South America.   *Maria Eugenia D'Alessandro* [1] - *Pablo Collins* [2]

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The natural environments provide to society different elements or services with economic values. Some of them are recognized by the society, and others are ignored such as the nutritional value. This is underestimated in the freshwater environments, even more, your variation in the year. The different species that are fisheries, or potentially can be captured offer nutritional components (micronutrients and macronutrients) essentials for life or improve the health. Among them, proteins of high biological value and fatty acids (essentials, polyunsaturated n-3, monounsaturated, among others) are elements to evaluate. The aim of work was to identify the services that the freshwater environment provides to the society in relationship to nutrition and health. The evaluation was realized in the fishes of economic interest in the Paraná River (*Prochilodus lineatus*, *Leporinus obtusidens*, *Pimelodus maculatus*, *P. albicans*, *Luciopimelodus pati*, *Pseudoplatystoma coruscans*, *Pterodoras granulosus*), and prawn species not commercialized (*Macrobrachium borellii* and *M. jelskii*). The fish catch volume was obtained from Official Register in fiscalization ports at Middle Paraná River, and data of crustacean decapods from bibliography. The protein and fatty acids (FA) contents of each species were obtained from the bibliography, and with these data were calculated the protein/lipid ratio, n-6/n-3 fatty acids relationship and sum of essentials FA (18:2 n-6, 18:3 n-3) and polyunsaturated fatty acids n-3 (PUFA n-3: 20:5 n-3, 22:6 n-3). In addition, a lipid index was calculated as a function among monounsaturated FA (18:1 n-9), essentials FA, PUFA n-3, 20:4 n-6 and saturated FA. Protein content and some FA levels were relativized according to the monthly catch of each species. The relation protein/ lipid was highest in prawns, and among the fishes, was higher for *P. granulosus* and lowest for *L. pati*. However, the highest protein content provided by the Middle Paraná River was supplied by *P. lineatus* due to the more catch. The relation n6/n3 was higher to 1 and lower to 2 in *P. maculatus*, *P. albicans* and *P. coruscans*. The values in the rest of the species were lower to 1. The lipid index was near to 2 for prawns, *P. maculatus* and *L. obtusidens* while in the rest of species was lower. The Middle Paraná River provides protein and

fatty acids (e.g. essentials and PUFA n-3) that oscillate with maximums along to the year due to the catch (summer, winter and spring), being highest in *P. lineatus*. The rest of species, maximum values were registered in autumn and winter but their capture volumes were smaller to *P. lineatus*. The variation of nutritional services of the Paraná River occurred in relation to quantity and quality of protein and lipid in each species and catch variation in the year. The results show resources of good quality nutritional. In the region exists others resource that not are used, e.g. prawns, thus today the value of the nutritional service is subestimated.

23. SHALLOW LAKES IN A WORLD OF CHANGING CLIMATE

23-O   Effects of temperature and trophic conditions in the grazing capacity and nutrient release promoted by the native bivalve *Diplodon paralellopipedon*.   *Soledad Marroni, Nestor Mazzeo, Juan M. Clemente, Claudia Fosalba, Juan P. Pacheco, Carlos Iglesias*

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Bivalves are important grazers in shallow subtropical systems and can be responsible of controlling phytoplankton biomass. However, it is not completely clear whether they are able to decrease phytoplankton biomass or conversely promote its development by facilitating the availability of nutrients. Eutrophication and warming may enhance each other, therefore understanding how these two factors interact in a grazing-phytoplankton interaction is important. With this aim the potential effects of increasing temperature over the filtration capacity and nutrient release of the native bivalve *Diplodon paralellopipedon* was tested in laboratory conditions.

We conducted a two-months laboratory experiment using five different temperatures (between 10 to 30ºC) and three different food densities (*Ankistrodesmus* sp. cultures; 30, 15 and 7 µg Chl *a* L^{-1} average). Animals were collected from natural populations, brought to the lab and fed with *Ankistordesmus* sp. Before starting, animals were exposed to the next experimental temperature (starting at 10ºC) for a two-week period. Individuals were starved 24 h before and put in a density of 1 ind L^{-1} in 4 L aquaria, each treatment replicated five times. To avoid effects of food scarcity, after 45 to 90 min (depending on temperature tested) individuals were moved to a new aquarium with the original food density, 3 times. Differences among treatments were explored using 2-way analysis of variance, with temperature and food density as main factors. Once the filter measurements concluded individuals were moved to clean low nutrient water to measure the amount of TP and TN released by the animals in a 6 h period.

No statistical differences on the filtration rates of *D. paralellopipedon* appeared for the different food concentrations tested. However, higher filtration rates were found at 20ºC (p<0.0001) and lower values were found at lower temperatures.

Nutrient release was not related to food density either. TP and TN concentrations had higher values at 20-25ºC and lower ones at lower temperatures.

Overall, our results suggest that bivalves response seems not to be affected by the Chl *a* available but to temperature, suggesting that grazing along the year might increase with temperature, particularly if the optimum 20ºC temperature is achieved earlier and remains for longer periods along the year, as predicted in some models. However, nutrient release was also enhanced by temperature, which might jeopardize the positive effects of direct phytoplankton removal. Moreover, as these organisms occupy the bottom of the lake they might differentially affect phytoplankton, particularly floatation regulators (e.g. cyanobacteria) might benefit by the removal of competitors and the resulting nutrient-enriched environment.

23-O   The role of tropical cyclones in stimulating cyanobacterial (*Microcystis* spp.) blooms in hypertrophic Lake Taihu, China.   *Mengyuan Zhu [1] - Hans Paerl [2] - Guangwei Zhu [1] - Tingfeng Wu [1] - Wei Li [1] - Kun Shi [1] - Linlin Zhao [3] - Yunlin Zhang [1] - Boqiang Qin [1] - Alicia Caruso [4]*

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Weather-related disturbances, such as wind-generated waves, major rainfall events and large temperature shifts associated with frontal passages, are important drivers of ecological processes in shallow lakes. The influence of Pacific tropical cyclones on cyanobacterial blooms in China's third largest lake, Taihu, was studied during the passage of two typhoons using a continuous monitoring as part of an on-lake high-frequency recording platform, coupled to satellite-based remote sensing data. Short-term (on the order of hours) nutrient pulsing resulting from the passage of typhoons played a key role in bloom initiation and maintenance. Decreasing wind speeds and increasing air and water temperatures in the aftermath of cyclones were accompanied by elevated phytoplankton biomass concentrations. The synergistic effects of nutrient pulsing, elevated water temperatures and increased water column stratification after the passage of the cyclones stimulated blooms of the toxic cyanobacteria *Microcystis* spp. There were short-term successions of blooms following typhoons, and as blooms "crashed" they provided nutrient inocula for future blooms. Trends determined from historical *in situ* data indicated higher frequencies and intensities of blooms in "cyclone years". Typhoons are an important driver of biogeochemical and water quality perturbations at the ecosystem-level in this hypertrophic lake. These events play a key role in our ability to forecast blooms over both short (days) and longer-term (weeks) periods.

23-O　Bioturbation is influencing CO$_2$ emission from shallow temperate lakes.　*Viktor Baranov* [1] - *Joerg Lewandowski* [1] - *Stefan Krause* [2]

Leibniz Institute of Freshwater Ecology and Inland Fisheries, Department of Ecohydrology, Berlin, Germany [1] - *University of Birmingham, School of Geography And Enviroment, Birmingham, United Kingdom* [2]

While lakes are occupying less than 2% of the total land surface of the earth, they are major players in the global carbon cycle. Shallow lakes, especially in boreal and temperate climate zones, are of extreme importance as sites of carbon sequestration. Several factors, such as primary production, the annual temperature cycle, lake morphometry, sediment respiration rate and organic matter are considered main controls of the efficiency of lake carbon sequestration. In this context, the impact of bioturbation (the biological reworking of sediment matrix and pore liquids) on sediment metabolism and respiration is underestimated, in particular as biological activity is likely to change with globally increasing water temperatures. We have conducted a series of microcosm experiments aiming to determine the impact of bioturbation of chironomid larvae (Diptera, Chironomidae) on lake sediment respiration. Chironomid bioturbation increases sediment respiration in microcosms up to 3-4 times compared to uninhabited sediments. Bioturbation impacts on sediment respiration increased with rising water temperatures. While at 5 °C sediment respiration rates with and without chironomids differed only insignificantly, at 30 °C sediment respiration in microcosms with 2000 chironomids per m^2 was 4.9 times higher than in uninhabited sediments. Our results indicate that lake water temperature increases could significantly enhance lake sediment respiration with severe consequences such as increased CO$_2$ release. Therefore, the importance of bioturbating benthic animals as drivers of enhanced sediment CO$_2$ release should be carefully examined when quantifying the consequences of global climate change for shallow lakes.

23-O　Broad-scale expansion of large, shallow lakes inundates critical wood bison habitat in Canada's great slave region.　*Joshua Thienpont* [1] - *Jennifer Korosi* [1] - *Michael Pisaric* [2] - *Myrna Simpson* [3] - *Terry Armstrong* [4] - *John Smol* [5] - *Linda Kimpe* [1] - *Jules Blais* [1]

Department of Biology, University of Ottawa, Ottawa, Canada [1] - *Department of Geography, Brock University, St. Catharines, Canada* [2] - *Department of Physical and Environmental Sciences, University of Toronto Scarborough, Toronto, Canada* [3] - *Environment and Natural Resources, Government of the Northwest Territories, Fort Smith, Canada* [4] - *Department of Biology, Queen's University, Kingston, Canada* [5]

In high-latitude regions, dramatic changes in water levels have been linked to climate change, with potentially negative consequences for the protection of vulnerable wildlife. In the Arctic and subarctic most attention has focused on shrinking lakes, however, here we document extensive expansion of large, shallow lakes in Canada's southern Northwest Territories that is flooding critical habitat for the Mackenzie wood bison herd (*Bison bison athabascae*), a genetically pure, disease-free herd of significance to conservation efforts for this environmentally important and charismatic species. We quantified lake area changes since 1986 in the Mackenzie Bison Sanctuary using remote sensing techniques based on Landsat imagery, and found that the proportion of the landscape occupied by water had nearly

doubled by 2011. Low-lying meadows identified as critical bison habitat experienced the greatest amounts of inundation. Inter-annual variability in lake size from 1986-2011 was significantly correlated with climate teleconnection patterns and local temperature/precipitation records. Despite drought-like conditions that have persisted in the region since 2013, water levels remain high. Historical reconstructions using plant biomarker and subfossil indicators archived in dated lake sediment cores showed the scale of recent lake expansion is unprecedented over at least the last several hundred years, and represents a fundamental alteration of the structure and function of an ecosystem critical to wildlife conservation efforts occurring in response to climate change. Our research also highlights the utility of a multi-disciplinary approach incorporating both paleolimnological and historical remote sensing techniques for tracking broad-scale environmental changes in subarctic regions.

23-O   Consequences of urbanisation and a drying climate on the management of groundwater dependent shallow urban wetlands.   _Mark Lund_

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The Yellagonga wetlands are shallow groundwater dependent ecosystems located in the urban area of Perth, Western Australia. Lake Joondalup has gone from being dry approximately once in every 20 years before 2000 to drying every year. Lake Goollelal also dried in 2011 for the first time since 1986. Both lakes dried to expose the sediment (a floc) however it remained wet. Declines in the water levels within the lakes are due to a combination of a lower groundwater table coupled with low direct rainfall. The unconfined groundwater table has been in decline due to reduced rainfall and abstraction for drinking water. Direct rainfall into Lake Joondalup accounts for over 50% of the total water inputs. Rainfall in the last decade has only exceeded the long term average in three years.
The floc protects the lakes from excessive nutrient concentrations though its large uptake capacity. If the floc was to dry, this capacity would be lost – as the floc is unable to reconstitute itself after drying. Further, pyrite within the floc, particularly in Lake Goollelal poses a substantial risk of acidification upon rewetting. Low water levels in the lakes appear to be the major determinant of nuisance midge (Chironomidae) plagues.
In this paper, we discuss how ongoing urbanisation around the lakes will most likely reduce nutrient inputs into the catchment especially compared to the previous use for market gardens and poultry farms. Urbanisation is predicted to increase groundwater and surface runoff into particularly Lake Joondalup mitigating predicted impacts of climate change. However Lake Goollelal remains at risk from increased drying due to climate change.

23-O   Warming advances phenology and increases biomass of a freshwater macrophyte.   _Mandy Velthuis [1] - Ralf Aben [2] - Garabet Kazanjian [3] - Sarian Kosten [2] - Sabine Hilt [3] - Edwin Peeters [4] - Ellen van Donk [1] - Liesbeth Bakker [1]_

Aquatic Ecology, Netherlands Institute of Ecology, Wageningen, Netherlands [1] - Aquatic Ecology and Environmental Biology, Radboud University, Nijmegen, Netherlands [2] - Ecosystem Research, Leibniz Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany [3] - Aquatic Ecology and Water Quality Management, Wageningen University, Wageningen, Netherlands [4]

Global warming is a severe ongoing threat to aquatic ecosystems. Since the 1960s, temperatures have been increasing at a rapid pace and are predicted to increase another 3-5 degrees over the coming century. Higher temperatures may lead to changes in productivity and energetic demands of an organism, and thus to possible alterations in growth rate and stoichiometry. Being at the base of the aquatic food web, submerged macrophytes provide amongst others food, oxygen, and habitat for other aquatic life. Changes in their growth and stoichiometry may have consequences for their palatability and nutritional quality for first order consumers. Here, we investigated the impact of warming on *Myriophyllum spicatum*, a freshwater submerged macrophyte common in Europe and invasive in the US and Canada. For this purpose, a 1000 l (1.2 m depth) indoor mesocosm experiment ran for one year, following temperate seasonal temperature dynamics, and a warmed (+4°C) scenario. We measured the growth, phenology and C:N:P stoichiometry of *M. spicatum*. In the warmed treatment, shoots of *M. spicatum* reached the water surface 87 days after the start of the experiment, which was 16 days earlier than in the control. Furthermore, overall plant volume infested in the warmed treatment was higher throughout the entire year of the experiment. During the conference, these results will be complemented with data on C:N:P stoichiometry.

23-O Effect of warming and primary producer dominance on the greenhouse gas balance of shallow lakes. *Ralf Aben [1] - Mandy Velthuis [2] - Edwin Peeters [3] - Leon Lamers [1] - Jan Roelofs [4] - Sarian Kosten [1]*

Department of Aquatic Ecology & Environmental Biology, Radboud University Nijmegen, Nijmegen, Netherlands [1] - Department of Aquatic Ecology, Netherlands Institute of Ecology, Wageningen, Netherlands [2] - Department of Aquatic Ecology And Water Quality Management, Wageningen University, Wageningen, Netherlands [3] - B-ware Research Centre, -, Nijmegen, Netherlands [4]

Although the effect of global warming on the production of greenhouse gases (GHG) in ecosystems has received much attention, the effect of warming on ecosystems showing alternative states, such as shallow lakes, is largely unknown. Shallow lakes play an important role in the global carbon (C) cycle by processing large amounts of C, making it crucial to understand how climate change affects their C cycling. They are known to be in either a phytoplankton-dominated state or in a state dominated by submerged (or floating) vegetation. Warming is known to favor the growth of phytoplankton and floating plants at the expense of submerged vegetation. As phytoplankton-dominated shallow lakes tend to show lower rates of primary production and higher rates of, in-lake decomposition than lakes dominated by submerged vegetation, we hypothesize that warming will particularly enhance GHG emissions from lakes in this state, thus diminishing their C burial.

To assess the interacting effects of warming and alternative states on GHG emissions and C balance in shallow lake systems, we conducted two controlled indoor mesocosm experiments including sediment, each lasting a full year. In the first year, mesocosms were set up to mimic shallow lakes dominated by phytoplankton, whereas in the second year submerged macrophytes (*Myriophyllum spicatum*) were the dominant primary producer. In both experiments the effect of warming was studied by simulating temperature dynamics of the current temperate climate and a warm (+4°C) scenario. Day and night water-atmosphere gas fluxes were measured every three weeks, using a closed chamber connected to a GHG analyzer, whereas ebullition was measured continuously by inverted funnel-type bubble traps. Warming caused significantly higher GHG emissions for both states, which was solely due to increased methane (CH_4) ebullition. However, as the submerged macrophyte state showed net uptake of atmospheric carbon dioxide (CO_2), whereas the phytoplankton dominated state showed net emission of CO_2 and higher ebullitive CH_4 fluxes, the latter state had 9 – 30 times higher GHG emission. The lower CH_4 ebullition in submerged macrophyte dominated mesocosms can possibly be explained by radial oxygen loss from roots, preventing CH_4 production and enhancing CH_4 oxidation in the rhizosphere.

Our study clearly shows that including the importance of climate change-induced shifts in alternative states is vital to understand GHG emissions from shallow lakes, and to make solid emission estimates for global warming scenarios.

23-O The impacts of permafrost thaw slump events on metals, nutrients, and primary productivity in upland tundra lakes, Mackenzie Delta region, Canada. *Adam Houben, Jules Blais*

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Shoreline permafrost thaw is widespread in Canada's western Arctic, and often transports large volumes of inorganic material to adjacent lakes. In the upland tundra lake region east of the Mackenzie River Delta, Northwest Territories, Canada, shoreline retrogressive thaw slumps currently occur along 6-17% of lakes and have been increasing in size and frequency in recent decades. Large reductions in DOC, colour (i.e. clearer lakes), and 2-10 fold increases in major ion concentrations have already been observed in these slump-affected lakes. Using a gradient of thaw slump disturbance, measured as the proportion of catchment area disturbed, we observed significantly higher concentrations of several trace metals in the water column, (e.g. uranium, strontium, and lithium), indicative of the thawed permafrost soils. Conversely, lower concentrations of several ubiquitous metals, (Fe, Mn, and Al,) suggest precipitation due to increased pH and complexation and sedimentation with the incoming siliceous slump material. Lakes with larger, recent thaw slump activity tended to have lower nutrients (N & P) and planktonic Chl-*a* concentrations than reference lakes. Regression analysis highlighted that Chl-*a* reductions could be as much as two-thirds in the most disturbed lakes. Additionally, we compared our Chl-*a* and TP results to 10 other studies across Canada, with an emphasis on similar low-Arctic latitudes, and suggest that slump-affected lakes are hot-zones for ecological change under the context of climate warming. In these already nutrient-poor systems, future climate warming will likely accelerate thaw slumping and further reduce primary productivity in similar tundra systems.

23-O   Driving forces for lake primary production in the early growing season.   *Gunnhild Riise*

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The eutrophic Lake Årungen is a typical SE-Norwegian lowland lake, located in an agricultural region susceptible to erosion. The lake is relatively shallow (mean and max depths are 8 m and 13 m, respectively), with a surface area of 1.2 km^2 and a theoretical water retention time of 4 months. Great efforts have been made, since the 1980s, to reduce the loading of phosphorous (P) from the surrounding catchment.

Annual measurements in Årungen during the first week of June (1999-2015) have revealed a significant increase in Tot-P concentrations. Whereas Tot-P increases in the whole water column (0.5 -13 m depth), phosphate (PO_4-P) only increases in the bottom layers. Uptake by biota in the photic zone and dissolution of PO_4-P in the bottom water is probably the reason for this gradient, since no oxygen depletion has been measured in the bottom water early in the growing season. Concurrent with increasing Tot-P concentrations, the concentration of particles have also increased. This indicate that erosive forces in the catchment promotes increasing loads of particles, either due to increased frequency of intensive rainfall events, prolonged ice free winter periods or changed management practices. The period from late winter to early spring is especially sensitive to climate changes, where large variability in precipitation and air temperature are shown to impact the nutrient inflow and time of thermocline formation in Lake Årungen. The time of for thermocline formation in the lake vary with more than a month; from mid-April to mid-May, depending on factors such as wind, discharge and temperature development. Most years show increased average monthly air temperatures during the spring months (compared to the normal period 1961-1990). However, there have been no significant increase for the whole lake temperature with time, but rather a decrease at 5 m depth close to the thermocline.

From this, we hypothesize that increased concentration of particles in Årungen have reduced the light transmission in the lake, and thereby reduced the heat transfer downwards through the water column, promoting a more shallow thermocline. In addition, the loading of particulate P has increased. Given large annual variability in major driving forces such as temperature, nutrients and light transmission, large variations in primary production is also expected. As an interplay of factors are driving the primary production in lakes, not only the nutrient supply, but also factors such as climate change and light conditions must be considered before costly abatement strategies are to be implemented.

23-O   El Nino influence on lake ice thickness.   *Ken Stewart*

Suny At Buffalo, University of Buffalo, Buffalo, USA

Several years of data on ice thickness have been obtained for two lakes in western New York State (USA). On each sampling date (every 5-7 days all winter), the ice thickness was determined by drilling through the ice at 4-8 sites and averaging the thickness from those sites. The influence of some El Nino winters is not always distinguishable from non El Nino winters. However, the El Nino winter of 2015-2016 clearly had an impact. For example (compared to other winters), the ice-on or complete freeze-over dates were later, the ice thickness was reduced, the duration of ice-cover was shorter, and the ice completely melted off both lakes during a mild mid-winter period.

23-O   Analyzing and forecasting the ecological and economic consequences of climate change for the water quality and local fisheries of large and shallow Lake Pyhäjärvi, Finland. *Anne-Mari Ventelä* [1] - *Tapio Keskinen* [2] - *Emmi Keskinen* [3] - *Teija Kirkkala* [4] - *Timo Marjomäki* [5] - *Juha Karjalainen* [5] - *Marko Jori* [4] - *Marko Lindroos* [3] - *Jouko Sarvala* [6]

Pyhäjärvi Institute, -, Kauttua, Finland [1] *- Natural Resources Institute Finland, -, Jyväskylä, Finland* [2] *- Department of Economics and Management, University of Helsinki, Helsinki, Finland* [3] *- Pyhäjärvi Institute, -, Eura, Finland* [4] *- Dept. of Biological and Environmental Science, University of Jyväskylä, Jyväskylä, Finland* [5] *- Pyhäjärvi Institute, University of Turku, Turku, Finland* [6]

Lake ecosystems are expected to face increasing pressure in the future both due to climate change and growing demand for food. Such changes will further challenge the ecosystem services such as clean water and fish production

provisioning fisheries, not least because nutrient loading and climate-warming effects act in synergy. Thus, adaptation and management actions are needed. Predicting future climate change is, however, difficult due to the high uncertainty regarding the large-scale dynamics, mechanisms and timing of the changes. In general, it is expected that the frequency and magnitude of extreme weather events will increase, which will further challenge the functioning and quality of lake ecosystems. In our case study, shallow and large Lake Pyhäjärvi (SW Finland), many climate induced changes have already been observed, and the local fisheries have been forced to adapt to the new conditions. We analyze and forecast the ecological and economic consequences of climate change for the water quality and local fisheries. Our result indicates that with successful adaptation both the water quality of the lake and the economic outcome of the fisheries may be even positive from management perspective, although it is clear that ecological and economic systems are not stable and will both be perplexed by many uncertainties and surprises. Thus, monitoring and detailed analyses and understanding of the long-term dynamics of lake ecosystems, key factors and interactions are needed to allow implementation of the climate change adaptation tools.

23-O Short and longer-term effects of an extreme DOC loading on trophic structure and metabolism in experimental lake mesocosms with contrasting nutrient levels and temperature.   *Erik Jeppesen, Martin Søndergaard, Torben L. Lauridsen, Thomas A. Davidson*

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Dissolved organic carbon (DOC) concentrations has increased in streams across northern Europe and North America resulting in more colored water in aquatic ecosystems. One of the explanations given for this increase is an increase in precipitation and not least in extreme rain. With climate warming we can expect a further increase in extreme rain events and likely then extreme DOC loading. To evaluate the effect of a sudden high dosing of DOC we added in April 2012 a brown DOC component (Huminfeed) to 24 flow-through (retention time 2.5 month) mesocosm lake system established and run uninterrupted since August 2003. The mesocosm system consists of three temperature treatments crossed with two nutrient treatments (high and low NP), resulting in six treatments with four replicates. The addition of Huminfeed led to an increase in TOC to 30-40 mg C l-1 and turbidity to 30-50 NTU, followed by an exponential decline over the following 3 month in both variables to the level before addition. Phytoplankton biomass (chlorophyll a) declined drastically, followed by a decline in both gross production (GPP) and respiration (ER). Less strong effect was found for bacterioplankton production, but low production in the low NP mesocosms indicates nutrient limitation of the bacteria. Using previous year data for comparison, the effect on GPP and ER declined markedly during the first three month, but was still apparent 9 month later. The negative effect was highest and lasted longer in the low NP mesocosms having submerged macrophytes. Accordingly, the macrophytes showed slow recovery (1-2 years). Our results showed that an extreme dose of colored DOC may have relative long-lasting effects on lakes, especially when NP is low.

23-O Impact of heat waves along with nutrient enrichment on zooplankton community structure: mesocosms approach.   *Uğur Işkın [1] - U.Nihan Tavşanoğlu [1] - Nur Filiz [1] - Erik Jeppesen [2] - Meryem Beklioğlu [1] - Yu Cao [2] - Erika M. Neif [3] - Torben L. Lauridsen [2] - Thomas A. Davidson [2] - Martin Søndergaard [2]*

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Shallow lakes, besides being the most widespread inland water bodies in the world are very sensitive to external perturbations, including land use and climate change. Today, unprecedented rates of warming threaten the functioning of lakes, especially when combined with additional multiple stressors as climate change itself also exacerbates the effects of stressors, especially eutrophication. Lately, extreme events e.g. -heat waves or flooding further complicate the impacts of stressors on ecosystem structure and functions. To elucidate the effects of nutrients and heat waves on zooplankton community structure and functioning we used 24 flow-through mesocosms (1.9 m in diameter, 1.5 m in total depth, imitating a shallow lake) located in Lemming, Denmark. The mesocosms simulate two nutrient levels, unenriched for control group and enriched with additional Nitrogen (N) and Phosphorus (P) combined with three different temperature scenarios (ambient, IPCC climate scenario A2, A2 + %50). Each of these treatment combinations were replicated four times. The heat wave treatment applied during a full month from 1st July 2014 till 1st August 2014.

During this period zooplankton community was sampled more frequently, after the treatment period, sampling frequency extended over time. Total sampling period is from 19th June to 9th October. Collected zooplankton samples are being identified, counted and measured for further analysis. Impact of treatments on the community structure of zooplankton will be discussed using several community parameters such as biomass, biodiversity, size diversity, richness etc.

23-O   Heat wave effect on lake metabolism as revealed by long term, high-frequency data.   *Vera Istvánovics, Márk Honti*

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During the last decade, several heat waves have passed Europe. These events may exert a pronounced influence on the functioning of lake ecosystems. Shallow polymictic lakes may particularly be sensitive to extreme hot periods due to both their low heat storage capacity relative to deep lakes and to strong temperature dependence of internal nutrient loads. The frequency of such weather extrema is expected to increase during climate change. To predict ecological status and related ecosystem services of lakes in a changing climate, limnological consequences of extreme hot periods must be understood.

High-frequency (1 to 40 minute) records of water temperature, wind, global radiation, turbidity, delayed chlorophyll fluorescence (a proxy of phytoplankton biomass) and concentration of dissolved oxygen were taken in shallow Lake Balaton during summers in the period 2008 to 2015. A heat wave was defined as daily mean water temperature exceeding 29.2°C in three consecutive days. This threshold represented the 5% hottest days between June and September (N=950), where daily mean water temperature was calculated from 1 minute temperature records of 5 sensors.

In three years (2008, 2009, 2014) no heat waves occurred, whereas in two years (2013 and 2015) two extreme hot periods were observed. The duration of heat waves ranged from 3 to 9 days; the longest period was in 2015. Gross and net primary production and ecosystem respiration were calculated by using a relatively complicated metabolic model, in which photosynthesis and autotrophic respiration were expressed as biomass specific rates. Temperature dependence of gross primary production and respiration was accounted for by the van't Hoff-Arrhenius equation. The model was simultaneously calibrated against time series of dissolved oxygen and phytoplankton biomass (delayed chlorophyll fluorescence) in a Bayesian framework based on sequential learning. As a typical pattern, ecosystem respiration doubled during prolonged heat waves. In contrast, delayed chlorophyll fluorescence tended to remain constant or decreased during heat waves and increased only in the subsequent cooling period. Thus, heat waves resulted in a prompt increase of respiration and in a delayed enhancement of phytoplankton biomass. This delayed response was most probably a consequence of increased internal nutrient load that favoured acquisitive, K-selected cyanobacteria.

23-O   Restoration of eutrophication in drought stricken lakes in mediterranean climatic region: a system of heavily eutrophic and relatively control lakes.   *Meryem Beklioğlu, Şeyda Erdoğan,- Arda Özen, Nihan Tavşanoğlu, Jan Coppens, Eti Levi, Tuba Buck, Gizem Bezirci, İdil Çakiroğlu, Nur Filiz*

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Two shallow interconnected lakes, Lakes Mogan and Eymir, situated on the Anatolian plateau in Central Turkey characterised by arid cold steppe climate with relatively eutrophic and hypertrophic conditions, respectively. The upstream larger Lake Mogan, which received minor amount of sewage effluent from the restaurants of the lake near shore, and the downstream smaller Lake Eymir, which received major sewage effluent of a suburban town (100,000 inhabitants) for over 25 yrs. The effluents in both lakes were diverted in 1995 and Lake Eymir was further biomanipulated in 1998-99 to aid the recovery of the lake by removing 50% of the lake's common carp and tench stock, water clarity increased nearly three-fold. This caused macrophyte coverage to expand from around 2.5 % to 40-90 % post biomanipulation. Five years later with the onset of the prolonged drought from 2003 until 2009, Lake Eymir had shifted back to a turbid water state. During the drought period, TP, TN and DIN concentrations increased in both of the lakes through internal mechanisms as there were very low inputs from the catchment. Drought period was also associated with 10-40 higher phytoplankton biomass especially with predomination of cyanobacteria (50- to 80% contributions). However, during the drought in Lake Mogan, macrophyte community remained high as long as it had

low water level which overridden the effect of increased nutrients. However, in Lake Eymir it did not. Wet period started onward 2010-present, significantly reduced the concentrations of nutrient and chl-a several fold and led to improved water clarity and allowed Lake Mogan to maintain it's macrophyte community, though which was very responsive to the water level. However, macrophyte did not recover in Lake Eymir. Then it was further biomanipulated, which resulted in improvement in water clarity similar to the condition occurred following 1st biomanipulation but not in macrophytes probably due to the higher water depth in Lake Eymir occurring lately during the wet periods.

Impact of drought, occurring frequently in Mediterranean climates and expected to be enhanced through climate warming, can be deleterious for nutrient rich lakes through further enhancing nutrients and overriding the effects of restoration efforts whereas in less nutrient rich systems, low water level may counterbalance the effects of eutrophication. Thus, reducing nutrient loading to lakes appeared to very critical for combatting the effects of drought.

23-O   Climate vs. land-use: diverging food-web effects on fish and invertebrate communities in shallow prairie lakes.

Bjoern Wissel [1] - *Peter Leavitt* [2] - *Ryan Cooper* [1] - *Elizabeth Starks* [1] - *Deirdre Bateson* [1] - *Lushani Nanayakkara* [1]

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The semi-arid climate and flat relief of the northern Great Plains result in large numbers of endorheic lakes, encompassing very diverse lake morphometries, water chemistries and food-web assemblages. Historically, food-web complexity was largely associated with salinity and lake morphometry. More recently, increased precipitation has been reducing salinity while intensive farming practices resulted in cultural eutrophication. These changes in climate and land-use are now potentially shifting food-web controls to winterkill as increased under-ice respiration often causes anoxia. To quantify the relative importance of these different environmental parameters for food-web composition we have been studying 20 lakes across the Canadian prairies since 2002. Our analyses identified diverging responses as fish assemblages are now controlled by winterkill while invertebrate communities largely depend on salinity (beyond changes due to reduced predation pressure). This work will be critical not only to develop new management practices to protect and improve current water quality and fish habitat, but also anticipate the impacts of future climate change, e.g., temperature stress in summer vs. reduced winterkill during milder winters.

23-O   Ypacarai Lake: evolution of the trophic state of a sub-tropical shallow lake and key factors to consider in remediation activities.

Juan Francisco Facetti [1] - *Juan Facetti-Masulli* [2]

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This article analyses the results of studies done at the Ypacarai Lake (Central, Paraguay) since 1942 to 2015. In this lapse a total of 17 studies of water quality and eutrophication have been published. In addition to the physicochemical and plankton parameters, special attention were given to key eutrophic index parameters as Total Nitrogen (TN), Total Phosphorous (TP), chlorophyll-a, light penetration, transparency, suspended sediments (SS) and bottom sediments (BS), iron as well as other 3d and refractory metallic elements analyzed (in both SS and BS). It is an iconic place for visitor because its landscape beauty and its recreational use and is surrounded by a rich nature and wetlands. Present population is about 800.000 inhabitants with an annual rate grow of 5%. Water level is very dependent of rains and in some degree to the Paraguay River flood. In 1992/1995 studies, average deep was about 1,8m., in 2007 it was 3.05m., and in 2015 decreased to 2.2 mt. indicating severe impacts of runoff. Sediments deposition by runoff show to be very important along the years. The lake has received in 2005 a total of 17.3T/day of BOD, 4.8 T/day of TN, 0,65T/day of TP and a high load of 211T/day of SM, from domestic wastewater, industrial effluents and diffuse sources (agriculture, cattle raising).

This lake changed from having a good water quality, used primarily for recreation and fishery, into a lake with almost no fishery and no recreational activities. In 1978 a good diversity of phytoplankton moved to only one dominant cyanobacterial species (Mycrocistis aeruginosa) in 2015. Frequency and extent of blooms increased since 1983. In 1942 and 1964 presence of colloids and iron was specially mentioned, naturally occurring colloidal substances reduce light penetration and the values in the scheme reflect this. Results from 1978 to 2015, show low transparency and weak unstable thermal stratifications. Fetch and winds promote extended, disseminated localized overturns. Its influence on

the phytoplankton was especially noted in 1984. Likewise, load inputs of BOD and TN due to domestic wastewater are much higher than those from industrial and diffuse sources. Nevertheless most of the input of P and SM results from diffuse sources incremented by the erosion process (new urban areas) and runoff. Analyzing the trophic state of Lake Ypacarai the mean level of TP the last 40 years ranged between 0.29 mg/L (in 1978) and 0.315 mg/L (in 2015). The level of TN ranges from 1.9 mg/L in 1984 to 2.45mg/L in 2014. In 2005 and subsequent years, the presence of Microcistine LR was reported in levels between 0.5 ug/L to 1 ug/L). And chlorophyll a varies that year between 5ug/L to 85ug/L. The article praise for more efficient restoration activities, sustained by robust analysis of key factors as sediments, colloids and iron.

23-O   Climate warming and hydrologic and biogeochemical change of shallow lakes in the Yukon Flats region of interior Alaska.   _Robert Striegl, Edward Stets_

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Yukon Flats is a greater than 30,000 km^2 region in the north central Yukon River basin of interior Alaska having more than 76,000 lakes. Low-lying lakes in this region are commonly less than two meters deep, ice-covered as many as eight months per year, and some may completely freeze to the lake bottom by late winter. They exhibit a wide range of chemical composition, ranging from dilute clear-water lakes, to lakes having high concentrations of dissolved solids that precipitate near shore in late summer. Differences in lake chemistry are thought to be largely attributable to the degree of hydrologic isolation from ground water and surface water flow systems by underlying permafrost. Chemical analyses of more than 200 lakes in Yukon Flats suggest that dissolved inorganic carbon (DIC) concentration, ^{13}C-DIC content, and dissolved organic carbon quality all change with lake evaporative state, as characterized by lake water deuterium and 18-oxygen content. Climate warming and permafrost thaw will have a wide range of effects on these shallow lakes, including increased hydrologic connectivity among lakes, potential draining through taliks (thawed sediments), and shifts in macrophyte and invertebrate communities important to waterfowl production. Warming and increased growing season length will also impact lake carbon dynamics and chemistry by potentially increasing macrophyte infilling of shallow waters, respiration, and greenhouse gas emissions.

23-O   Change in the rhythm of floodplains and their consequences for plankton diversity and local populations.   _Cleber Kraus [1], Leonardo Gomes[1], Maria Tereza Lobo[2], Marie-Paule Bonnet[3], Ludgero Vieira[1], Ina Nogueira[2]_

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The moving littoral enables a rapid nutrient recycling, explaining the large productivity and biodiversity of the Amazonian floodplain system. Attracted by such favourable conditions for agricultural activities and fishing, populations have settled in the floodplains and developed complementary activities to cope with important variations in their environment, between the flood season and the dry season. However, in the past decades, the rhythm of these floodplains has changed. Based on years of hydrological and biogeochemical studies to understand the reasons of these environmental changes, coupled with recent studies of planktonic communities, we choose the floodplain of Curuai on the Amazon basin to try understanding some questions: The increase in these activities is affecting the water quality? If affected, which factors are the most critical for the local population to repair possible damage without harming their activities?

Our preliminary results based in our data, has shown that the floodplain of Curuai presents a delicate balance that has been disturbed. These disturbances are related to changes in rainfall patterns in the region, increasingly intense drought and floods events and increase population activities. Planktonic communities respond quickly to this changes in floodplains and can act as good indicators of the quality of these systems. Increase in planktonic biomass is common during the high water period, but our team has observed that the different activities carried out in different phases of the pulse has had local effects that contribute to further degradation and more intense blooms of cyanobacteria. The factor that has limited the planktonic growth is nitrogen, since other nutrients, such as phosphorus has its relatively constant levels throughout the year. The beta diversity analysis shows a major contribution of the turnover fraction in

the composition of planktonic communities. This community structure together with the different limnological characteristics of each sample unit show that the diversity and balance of floodplain, depends on the complex interactions. In general, we found that the health of the floodplain is not compromised yet, but the increasing intervention of human activities, combined with changes in weather patterns, can cause severe disturbances in future scenarios.

23-P   Temporal and spatial changes in *Trapa* and *Nelumbo* covering in a shallow eutrophic lake, Lake Sagata, Japan, with special references to lotus dynamics.   *Haruo Fukuhara* [1] *- Tohru Yanagisawa* [2]

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Temporal and spatial changes in *Trapa* and *Nelumbo* covering of a shallow lake, Lake Sagata, were investigated based on aerial photographic analysis. L. Honsagata (37° 49' N, 138° 53' E, open water area: 35.5 ha), one of two water bodies of sand dune Lake Sagata, was chosen for a study site, because of a moderately eutrophicated habitat for macrophyte growth and possible usage of accumulated data of aquatic vegetation. This Lake is continuously fed by agricultural nitrate-rich waste water through many springs around the lake. Both the emergent and floating-leaved plants can grow anywhere in a lake because of shallow depth (0.5 - 1.5m). The dominant macrophytes in the lake are *Nelumbo nucifera* and *Trapa* spp. (*T. natans* and *T. japonica*), and sometimes *Euryale ferox*. The covered areas of macrophytes were estimated from the data cited in previous papers and aerial photographs taken over Lake Honsagata. During the continuous or discontinuous 18 calculable years after 1984 to 2011, the total macrophytes vegetation area annually showed marked changes, from 46% to 98% over the whole water surface. *E. ferox* appeared largely in 1984, 1988, 2010 and 2011 (8 - 40%), but rates of covering of this species were below 1% in other years. Rates of the growth area of *Trapa* spp. to the total area ranged from 3% in 2001 to 80% in 2011. Covering area reached to peak in the beginning of 1990s and 2010s in studied years. *N. nucifera* covered 4% in 1988 and 75% in 1997 in total area. Growth area of *N. nucifera* increased toward the end of 1990s and decreased to the beginning of 2000s, and again increased toward the end of 2010s. From the analysis of 741 quadrats (20 x 20m) set imaginarily in the lake, forty four quadrats (6%) maintained *N. nucifera* stand over 7 in continuous 10 years, especially 2 quadrats maintained stands during 10 years with average of 4.0 (SD=1.7) years. Expansion speed of *N. nucifera* stand developing one direction was about 20 m per year and disappearing speeds ranged from 4.0 to 38.0 m with average of about 15 m per year. Significant inverse correlation was admitted between covering area of floating-leaved plants *(Trapa* spp. and *E. ferox*) and that of *N. nucifera*. The possibility of regulation of growing area of the annual floating-leaved plants by an emergent perennial *N. nucifera* is discussed. Also annual dynamics of covering of macrophytes are discussed with the relation to environmental factors temperature, amount of insolation, water level fluctuation, sediment nutrition, and effects of an injury by continuous cropping.

23-P   The effectiveness of nutrient reductions for mitigating the response of algal blooms to climatic extremes (hot and/or dry summers).   *Helen Woods , Laurence Carvalho, Bryan Spears, Alanna Moore, Philip Taylor, Linda May*

Centre For Ecology & Hydrology, N/a, Edinburgh, United Kingdom

The development of algal blooms in freshwater lakes has a major impact on water resources worldwide. Excess nutrients, in particular phosphorus, are often considered to be the main factor underlying the development of these phytoplankton blooms. However climate change, leading to increased summer temperatures and drought, is hypothesised to increase the severity, frequency and duration of algal blooms. Multiple stressors may act synergistically or antagonistically, but at present it is unclear how climatic extremes of rainfall and temperature impact on algal blooms, and if these stressors interact with lake nutrient status. Here we investigate the summer algal growth response under these multiple stressors using 30 years of data from Loch Leven, a lake in Scotland, UK. A significant effect ($p<0.05$) of rainfall on chlorophyll-a is reported, as well as a significant interaction between loch nutrient status (winter total phosphorus (TP)) and rainfall ($p<0.05$). No significant effect of temperature extremes was detected. Chlorophyll-a levels under dry summer conditions are on average, 12 µg L^{-1} higher than in wet summers, but there appeared to be little independent effect of TP. The interaction with rainfall appeared to be associated with wet summers, where the detrimental impact of a wet summer on algal growth was dependent on TP concentrations, with high TP levels allowing

phytoplankton to reach comparable levels to summers with dry conditions. The consequences of these results will be discussed, including the unexpected lack of response to warmer summer temperatures. In broad summary, the results suggest that it remains important to reduce nutrient loading to lessen the severity of algal blooms in lakes, with benefits particularly seen in wetter summers.

25. HIGH-THROUGHPUT SEQUENCING AND OTHER MOLECULAR TOOLS IN FRESHWATER ECOLOGY

25-O   NGS Revolution: high-throughput exploration of biodiversity with molecular tools.   *Monica Santamaria [1] - Caterina Manzari [1] - Claudia Lionetti [1] - Marinella Marzano [1] - Bruno Fosso [1] - Bachir Balech [1] - Teresa De Filippis [2] - Giuseppe Sgaramella [1] - Anna Maria D'Erchia [2] - Carmela Gissi [2] - Graziano Pesole [2]*

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The increasing demand for low-cost and effective DNA sequencing for an amazing variety of application fields has driven the development of high-throughput DNA sequencing platforms also termed Next Generation Sequencing (NGS). Since their first appearance on the market, about a decade ago, NGS has experienced incredible progresses in terms of sequencing accuracy, read length, overall throughput and cost reduction. Several DNA sequencing platforms are currently on the market, using different strategies and chemistries, and meet specific user requirements and application areas. Furthermore, third-generation systems are on the way and promise further substantial improvements.

The advent of NGS has also opened new avenues for exploring biodiversity at an extent previously unimaginable. In particular, a variety of metagenomic approaches have been developed that may provide an accurate and cost-effective assessment of the overall microbiome composition at qualitative and quantitative level in any environmental sample, including water, soil, air, sediments, thus greatly expanding our knowledge about the taxonomic and functional biodiversity existing on our planet.

Microbiome investigations by metagenomic approaches bypass the need for laboratory cultivation and / or isolation of individual species/strains as well as their biochemical or morphological identification which results problematic in many cases. Actually, many cryptic species have been discovered and characterized by molecular approaches.

Two alternative strategies can be employed, namely: i) target-oriented metagenomics, and ii) shotgun metagenomics. The first one consists in the massive parallel sequencing of a specific target region (e.g. 16S rRNA) from amplicons obtained by using primers specific for a given (the larger as possible) taxonomic group. The second one consists in shotgun sequencing of all the genetic material (DNA or RNA) extracted from an environmental sample. The first approach is possible only when an ubiquitous target region is amplifiable in (almost all) the taxa under consideration. When this is not possible, e.g. to investigate viral diversity, the shotgun approach is the only option. It should be also noted that the first approach provides only the taxonomic diversity, while the second one can also investigate the functional diversity of the sample.

The critical bottleneck of metagenomics approaches is the complex bioinformatics analysis of NGS data which requires accurate and computationally efficient workflows, such as BioMas (Fosso et al., 2015) we recently developed, as well as unbiased reference databases.

25-O   Connectivity facilitates local adaption of lake bacterioplankton.   *Theresa Lumpi*

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In the context of global change and species diversity loss, understanding relationships between diversity and ecosystem functioning has become particularly important. Therefore, it is necessary to investigate underlying mechanisms that generate and maintain diversity patterns across spatial scales. In natural environments, local communities typically resemble a small part of a metacommunity and are hence influenced by regional factors such as dispersal.

In this study we examined the effects of connectivity along with important environmental parameters on freshwater microbial communities. The experiment consisted of a metacommunity composed of mesocosms (300 L, n=40) inoculated with water from three different lakes in Lower Austria. We manipulated nutrient regime, presence of zooplankton and connectivity to an external source pool in a full factorial design. We sampled water by filtration on three occasions spanning a 4-week period and used PCR amplification and high-throughput sequencing of the 16S rRNA gene to assess differences in bacterial community composition and diversity between treatments and over time.

Time was the single most important factor on bacterial community composition, yet all treatments had significant effects within each time point. Connectivity alone had only weak effects in the absence of other experimental

manipulations. However, strong interactive effects on community composition were evident in combination with zooplankton grazing and enrichment.

Consequently, the shift in the bacterial community was not only influenced by local environmental factors or regional processes but depended especially on the combination of these factors. Supporting the metacommunity concept and the idea of connectivity as a key driver for local species composition, our findings illustrate that connectivity shows strongest effects in interaction with the local environment and thus favors local adaption of bacterioplankton communities.

25-O   The use of next-generation sequencing to distinguish microbial communities under the influence of different land use in groundwater ecosystems.   *Karczewski Karsten, Riss H. Wolfgang, Meyer Elisabeth I.*

Institute of Evolution and Biodiversity, Department of Limnology, University of Münster, Münster, Germany

Groundwater comprises 94 % of the usable freshwater and is the most significant freshwater resource. An important ecological function is their contact to surface aquatic ecosystems, which for their part are dependent on the communication with aquifers. Most groundwater ecosystems are of pristine quality and thus characterized as oligotrophic environments with low energy yield, activity, growth, and reproduction. There, microbes are the most abundant organisms. Their metabolic functions substantially contribute to purification of groundwater, being considered as a significant ecosystem service. Anthropogenic activities, on the other hand, can strongly influence the structure and composition of these communities, as alterations within these fragile micro-habitats may turn into environmental stress and give a selective advantage for more resistant species. The entailed changes in the structure of groundwater species communities, are associated with the degradation of groundwater quantity and quality. Despite an increasing awareness of this problematic, current assessment methods for groundwater ecosystems are based on the analysis of abiotic parameters only and insufficient to detect changes of the microbe communities and thus ecosystem functioning. Against this background, the present study intends to render information about effects of environmental stress at different levels of biological organization. By use of next-generation sequencing (NGS) we targeted species identification for microbe communities sampled from aquifers and springs under different degrees of land use impact. Differences in community structure were analyzed and interpreted against the concentration of abiotic substances as a measure of stress on biota. First results show that sampling areas can be differentiated according to the land use factor, whereas patterns of community structure on a smaller scale within sampling areas remain inconsistent.

25-O   The future of stream monitoring: DNA metabarcoding!   *Vasco Elbrecht, Florian Leese*

Aquatic Ecosytem Research, University of Duisburg-Essen, Essen, Germany)

The macrozoobenthos is an essential part of stream ecosystems, and macrozoobenthic indicator taxa are widely used for assessing and monitoring stream health. Unfortunately, morphology-based identification of invertebrate larvae is often only possible to an unsatisfying taxonomic level, time-consuming, difficult and the results highly depend on the experience of the analyst. This can lead to inaccurate ecosystem assessment and thus inefficient stream management. An alternative method, which allows reliable species level identification, is DNA-based. Individual specimens can be identified by sequencing a short standardized DNA fragment (Cytochrome oxidase I) and comparing it to a reference database. DNA metabarcoding relies on the same principle, but can identify thousands of specimens of a single sample using recent advances in sequencing technology.

We present our cutting edge metabarcoding protocol for monitoring of stream ecosystems. Our experiments show that DNA metabarcoding is best suited for generating presence / absence data and biomass estimation will be difficult with DNA based methods. However, we were already able to reliably detect and identify 83% of taxa present in artificially constructed bulk benthos sample. Additionally, we explored the utility of 16S as a marker, which shows reduced primer bias but is limited by the lack of adequate reference data. Finally, presorting by specimen biomass was tested on complete kick samples, which lead to more homogeneous read distributions.

The proposed DNA metabarcoding protocol has been extensively tested and verified against mock communities and complete kick samples. Taxonomic resolution is doubled compared to morphologically identified communities. Despite several technical and conceptual challenges we are confident that it can be applied for routine monitoring of macroinvertebrate diversity soon.

25-O   DNA waterscan: linking molecular identification to functional traits to assess freshwater quality.   *Berry van der Hoorn* [1] *- Arjen Speksnijder* [1] *- Kevin Beentjes* [1] *- Tiedo van Kuijk* [1] *- Michiel Hootsmans* [2]

Naturalis Biodiversity Center, Naturalis Biodiversity Center, Leiden, [1] *- Kwr -watercycle Research, Naturalis Biodiversity Center, Nieuwgein,* [2]

Monitoring biodiversity is of crucial importance to assess ecological quality. Such information enables authorities to address environmental problems and their appropriate solutions. In the European Union the Water Framework Directive (WFD) is an important legislative driver necessitating detailed information on the ecological status and effective management of freshwater bodies.

Water boards in The Netherlands are spending large budgets to fulfill the demands of the WFD. They also invest in quality assessments of water bodies that are outside the scope of the WFD but which may be even more important from an ecological perspective. In traditional monitoring, sampling is done according to pre-defined protocols, collected biodiversity is sorted out, individual species are morphologically identified and specimens are counted. These routine activities are labor intensive and require specialist expertise, which is far from cost-effective. Due to differences in taxonomic expertise among collectors the identification of taxa is prone to errors and hence uniformity among processed samples is lacking.

The project DNA Waterscan aims to develop a freshwater diagnosis tool based on the occurrence of macroinvertebrates in water bodies. Species are identified using metabarcoding of blended samples of organisms or with environmental DNA obtained from water samples. We set up a reference collection with voucher specimens and their DNA barcodes for all the macroinvertebrate species occurring in The Netherlands. Well identified specimens are provided by a network of professional and amateur scientists. We developed a bioinformatics pipeline to assemble reads and blast (mini)barcodes against our own reference databases, and those of BOLD and GenBank.

Encountered species compositions will be linked to their biological traits and environmental variables (ecological response curves) to assess the ecological quality of the water body from which the sample was taken. We are developing an ecological framework with traits and response curves per species, per community and per water type. We will benchmark the water bodies within a water type to provide water managers with information on the current status of the measured water body compared to the most healthy water bodies. This ecological assessment unit will be integrated in our bioinformatics pipeline. The DNA Waterscan tool is expected to contribute significantly to more uniform and cost-effective monitoring of freshwater quality.

25-O   Sedimentary DNA reveals phylogenetic diversity of cyanobacterial communities linked to environmental change over the last century.   *Marie-Eve Monchamp* [1] *- Piet Spaak* [1] *- Francesco Pomati* [1] *- Jean-Claude Walser* [2]

EAWAG, Eth Zurich, Duebendorf, [1] *- Genetic Diversity Centre, Eth Zurich, Zurich,* [2]

Human activities have greatly impacted lake ecosystems over the last centuries. Several lakes underwent accelerated eutrophication, which promoted phytoplankton growth and increased the occurrence of harmful cyanobacterial blooms. Reduction of phosphorus loadings contributed to a return to a lower trophic status (re-oligotrophication) in many lakes, but cyanobacteria often continued to dominate the phytoplankton community, impairing ecosystem functioning and water quality. Due to the lack of monitoring data on natural phytoplankton assemblages before eutrophication, the long-term responses of cyanobacterial communities to rapid changes in trophic conditions remain poorly understood. However, the development of massive parallel sequencing and improved protocols for retrieving DNA from environmental samples in recent years allowed to bridge this gap. In this study, we investigated the dynamics of cyanobacterial communities across a trophic gradient over the last century in sediment records of peri-alpine lakes. We used high throughput short-amplicon DNA sequencing to explore changes in phylogenetic diversity and biogeographical distribution of cyanobacteria. Multivariate community analysis showed that cyanobacterial communities shifted through the periods of pre-, mid-, and post-eutrophication, suggesting that the structure of communities is highly sensitive to environmental conditions. This study highlights the potential of using high-resolved

phylogenetic data from sediment records to investigate planktonic community dynamics and disentangle the roles of climate and local environmental change in shaping phytoplankton communities.

25-O   The molecular effects of pesticides employed in organic agriculture (Copper and azadirachtin) on a wild population of *Chironomus Riparius* (Diptera Chironomidae).   *Valeria Lencioni* [1] - *Valentina Grazioli* [1] - *Matteo Gaglio* [2] - *Francesco Bellamoli* [1] - *Bruno Rossaro* [3] - *Paola Bernabò* [2]

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Pesticides may runoff from land into aquatic ecosystems. Therefore, it is crucial that the risk of harm to aquatic organisms is evaluated before wide-scale use is approved. Copper (Cu) and azadirachtin (AZA) are pesticides allowed in organic agriculture whose environmental risk and toxicity for aquatic wildlife is only partially known. The effects of these two pesticides were evaluated in a non-target species, *Chironomus riparius* (Diptera, Chironomidae), with multiple approaches, from ecotoxicological to molecular analyses. Fourth-instar larvae were collected from a mountain stream (Rio Gola, Trentino, Italy) polluted by run-off of agricultural land, and exposed for 3 and 24 h to different concentrations of the two pesticides. The mortality rate (acute toxicity tests) and the expression alterations of two families of genes, including one related to the cellular stress response (*hsps*) and one to metabolic detoxification system (*cyP450*), were assessed by qRT-PCR. For the more toxic pesticide (Cu), the effect of the stress was studied also by polysomal profiling and the detoxification capacity was assessed by enzymatic assay of CYP450 activity. Finally, the genotoxicity of Cu was evaluated by use of the alkaline Comet Assay.

All candidate genes (*hsp70*, *hsc70*, *hsp40*, *hsp10*, *cyP450*) resulted pesticid-responsive but each gene resulted differently regulated by different stress concentrations and different exposure time. Few similarities in expression profiling were observed such as the linear concentration-dependent response of *hsp70* after 24 h of exposure; the up-regulation regardless of the concentration of *hsc70* after 24 h of exposure; the up-regulation of *hsp70* after 3 h of exposure at LC_{50} (Cu-LC_{50}= 26 mg l^{-1}, AZA-LC_{50}= 1 mg l^{-1}). Polysomal profiling analysis highlighted unknown post-transcriptional regulation mechanisms for the five candidate genes and a key role of CYP450 in response to short term exposure to Cu. These results were supported also by enzyme assay, as CYP450 activity increased with increasing Cu concentration. Cu was also found to have genotoxic activity as demonstrated by significant increases in all the comet parameters (e.g., %DNA in tail) at the tested concentrations. Altogether the results highlighted a different toxicity of the two pesticides and the capacity of *C. riparius* (known as euriecious species resistant to heavy metal pollution and anoxia) to survive chemical stress. This resistance involves the synthesis of specific molecular chaperons and oxidative enzymes.

Finally, new insights are given on the potential role of the *C. riparius*'s *hsps* and *cyP450* genes as sensitive biomarkers of freshwater monitoring and on different experimental approaches that might be used to assess the environmental risk of pesticides in aquatic ecosystems.

25-O   Molecular diagnostics to identify fish: from trophic interactions to environmental DNA.
Bettina Thalinger, Johannes Oehm, Hannes Mayr, Christiane Zeisler, Michael Traugott

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The morphological identification of fish samples can be difficult when dealing with eggs, larvae, tissue samples, or feces and regurgitates of piscivores. For example, in fecal samples hard parts such as otoliths, chewing pads, pharyngeal bones or scales can be present, but their species-specific identification is in many cases not possible. Moreover, the monitoring of fish populations in general is time consuming and costly using conventional methods. In such situations, DNA-based approaches can provide a new means for fish identification and monitoring.

Here, we present a two-step multiplex PCR system, composed of six assays, tailored for rapid, sensitive, and specific detection of Central European fish species in environmental samples. It covers 79 fish and lamprey species and enables the identification of 31 species, six genera, two families, two orders, and two fish family clusters. Originally, these assays have been designed to detect fish DNA in dietary samples and were successfully applied to identify fish prey in feces of the Eurasian otter, the Common Kingfisher, as well as feces and regurgitated pellets of the Great Cormorant. The systems cost-effectiveness and capability to obtain fast and reliable results already led to its application in a large field study on cormorants.

Besides its suitability for ecological investigations of European piscivores, the high sensitivity and specificity of the multiplex PCR system enables its use in environmental DNA (eDNA) studies. Currently, the systems potential to detect DNA of alpine fish species in water samples is testes via field and laboratory experiments in comparison to a next generation sequencing approach. Additionally, quantitative PCR (qPCR) will be used to draw conclusions about the relative abundance of specific fish species. In a final step, the molecular approaches outlined above will be compared to conventional electrofishing to evaluate their applicability and reliability for studies on fish phenology, distribution, and population density.

25-O   Impact of large-scale weir construction based on community structure, health, and diet composition of fishes in a large river ecosystem (Nakdong River, S. Korea).   *Hyunbin Jo [1] - Erik Jeppesen [2] - Marc Ventura [3] - Maurice Lineman [1] - Jeong-Soo Kim [1] - Hyun-Woo Kim [4] - Gea-Jae Joo [1]*

Department of Biological Sciences, Pusan National University, Busan, Republic of Korea, [1] - Department of Bioscience, Aarhus University, Silkeborg, Denmark [2] - Centre For Advanced Studies of Blanes, Spanish National Research Council (ceab-csic), Blanes, Spain [3] - Department of Environmental Education, Sunchon National University, Sunchon, Republic of Korea [4]

Habitat alteration (i.e. weir construction) affects aquatic community structure in riverine ecosystems. Recently, 16 large-scale weirs were built in the main channels of the four largest rivers in South Korea. Specifically, 8 large weirs were constructed along the main channel of Nakdong River (300 km, 514 km in total) between late 2009 and 2011. River depth changed from 1-2 m to 6-7 m, while river width changed from 240-300 m to 350-530 m. To assess the impact by weir construction, we conducted an intensive seasonal fish survey including interviews of fishermen and used a molecular analysis approach to determine the diet composition of the top-predator largemouth bass (*Micropterus salmoides*) in the Nakdong River during 2005~2014. The seasonal survey data were divided into three groups relative to construction period (before 2005-2009, n=17; during 2010-2011, n=8; after 2012-2014, n=12). The results indicated that species diversity declined steeply during the construction period and did not recover notably afterwards. Fish total biomass also declined. However, after construction a slight recovery was traced. The information obtained from the fishermen interviews was compared with the seasonal fish survey data. The overall state of the fish community (weight-length relationship) was good "before", poor "during" and average "after". Specifically, the abundance of exotic species increased steeply after construction, whereas native species showed a decline following construction. Interestingly, there seemed to be no effects of construction on the total biomass and condition of invasive species (e.g. *Opsariichthys uncirostris amurensis*). A comparison of the diet composition (operational taxonomic units: OTUs) of top predators during the construction period showed that construction impacted the number of OTUs found in the gut contents. Thus, large-scale weir construction not only influences fish community composition but also the diet of the top predators in the associated large river ecosystem. These fish community and diet changes likely reflect qualitative and/or quantitative modification in benthic or planktonic production caused by habitat alteration in the large river ecosystem.

25-O   Environmental DNA and aquatic beetles: integrating molecular tools into freshwater macroinvertebrate community assessments.   *Kevin Beentjes, Arjen Speksnijder, Berry van der Hoorn, Menno Schilthuizen*

Naturalis Biodiversity Center, Leiden, Netherlands

The DNA Waterscan project at Naturalis Biodiversity Center aims to integrate molecular biological tools into the field of freshwater quality assessments. Its objectives are to develop molecular tools to detect freshwater macroinvertebrates communities, in order to make water quality assessments easier, cheaper and more standardized. This project is driven mainly by the EU Water Framework Directive (WFD), which lists species that are positively or negatively correlated with freshwater quality parameters. Compared to physical and chemical properties, biological indicators are much more capable of offering an integrated assessment of the "health" of water bodies. The use of benthic macroinvertebrates has several advantages, as communities are abundant, and reflect local conditions thanks to the limited migration patterns of many taxa. Their communities are made up of species that represent a broad range of trophic levels, ecological SIL functions and tolerances to stressors. The sampling of benthic macroinvertebrates is relatively easy and cheap, with minimal effect of the sampling on the resident biota.

Within the project, we are working on the optimization of both bulk and environmental DNA (eDNA) extraction methods for invertebrates, as well as metabarcoding techniques to capture the diversity of life, using aquatic beetles as one of the main taxon groups under study. Since aquatic beetles (and macroinvertebrates in general) and their DNA behave differently from more commonly studied taxa such as fish and amphibians, the usual methods for detection may be of limited use. An analysis pipeline will be developed together with partner organizations in the field of freshwater ecology and quality monitoring, to enable more uniform and reliable monitoring of species present in freshwater bodies. The results may be applied to 1 the assessment of water quality based on DNA circumventing morphological analysis, 2 the early detection of exotic species or potentially harmful invasive species, and 3 the detection of (potential) vectors of human or livestock diseases in the tropics.

At the very least, the cumbersome morphological sorting and identifying of macroinvertebrate samples can be replaced by molecular tools, eliminating a significant source of error which has been proven to exist in various audit studies. The ideal situation would work towards eliminating the need of specimen collection in its entirety, although much work needs to be done before any such method will become standard practice. By adapting strategies to better fit the needs of macroinvertebrate detection and identification, we can open up the field of molecular freshwater monitoring to much more integrative approaches of defining communities and assessing freshwater health. We will present our recent findings on the topic of macroinvertebrate identification and detection, and discuss the implications on the applicability of molecular tools for the study of macroinvertebrate communities.

25-O   Proteomic evidence of methanotrophy in methane-enriched hypolimnetic lake water.   _Nina Ullrich [1] - Peter Casper [1] - Andreas Otto [2] - Mark O. Gessner [3]_

Leibniz-institute of Freshwater Ecology and Inland Fisheries (IGB), Stechlin, Germany [1] - Institute of Microbiology, Ernst-moritz-arndt University, Greifswald, Germany [2] - Leibniz-institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin Institute of Technology (TU Berlin), Berlin, Germany, [3]

Methane is one of the most potent greenhouse gases. Formed primarily in anoxic sediments, methane can be released into the overlying water of surface waters and ultimately to the atmosphere. However, emissions are mitigated by effective methane oxidation when oxygen is present, mostly at oxic-anoxic interfaces. The objective of the present study was to adopt a proteomic approach to identify effects of methane concentration in oxygenated lake water on patterns of enzymes involved in methanotrophy. We collected bacterial communities in natural lake water from the oxygenated hypolimnion of a deep temperate lake, allocated the water samples to six flasks that were subsequently aerated and either enriched with methane or left untreated to serve as controls. After one week, proteins were extracted from the water of each replicate flask, digested with trypsin, the resulting peptides partially separated by gel electrophoresis and then analysed by LC-MS/MS connected to an EASY-nLC II system. Methane was effectively oxidized when methane concentrations were high, reducing oxygen levels from 12 to 3 mg/L, well below those in the controls (7 mg/L). The key enzyme of methane oxidation, methane monooxygenase (MMO), was identified in both enriched and control flasks, whereas enzymes involved in metabolic pathways leading to carbon assimilation related to methane oxidation (RuMP pathway and serine cycle) were restricted to the enriched microcosms. All enzymes had best sequence matches with type I methanotrophs. Therefore, the detection of enzymes required for the serine cycle was unexpected, since this pathway is considered characteristic of type II methanotrophs. However, we did not detect the truly specific enzymes of the serine cycle, hydroxypyruvate reductase (HPR) and serine hydroxymethyltransferase (STHM). This might imply that the four identified enzymes involved in the serine cycle assumed metabolic roles independent of methane metabolism (e.g. in carbohydrate metabolism). Overall, our proteomic analysis provides convincing evidence that a suite of genes required for methanotrophy are quickly expressed when the presence of both methane and oxygen creates conditions characteristic of oxyclines in lakes.

25-O   A lake's microbiome: from zooplankton to sediments.   _Ester Eckert [1] - Stefano Amalfitano [2] - Andrea Di Cesare [1] - Gianluca Corno [1] - Diego Fontaneto [1]_

Institute of Ecosystem Study ISE CNR, MEG, Verbania, Italy [1] - IRSA CNR, Rome, Italy [2]

This study determines and compares the microbiomes of various microenvironments representing different spatial niches within a lake ecosystem. We sampled three coastal stations of Lake Maggiore and sequenced the 16S rRNA gene of the bacterial communities associated with daphnia, copepods, and those living in water samples at 10 and 40m depth,

in the upper sediment layer, and in epilithic biofilms at the shore. We hypothesised that the animal associated microbiomes were less diverse (thus more specialised) when compared to the other habitats, due to the specificity of a microenvironment associated to an animal.

The total microbial community comprised little less than 3500 operational taxonomic units (OTUs). Most of these OTUs (i.e., 1978) were found uniquely in the sediment, which was clearly the habitat with the highest diversity, followed by epilithic biofilms, 40m-deep waters, 10m-deep waters, and copepods and daphnids at last. Beta-diversity analysis showed that both daphnia and copepod harboured a similar microbiome, since they clustered into the same. This animal cluster then grouped with the water samples (10 and 40m), and the so-formed animal-water group clustered with the stone microbiome. The most distant group contained the sediment microbes. Comparing the different niches, each habitat-pair shared between 107 and 254 OTUs, thus a similar amount of OTUs was shared between all couples. Considering non-rare OTUs (>10 reads in dataset, around 700 OTUs), 55% were found in only one habitat, with an average of 29 reads per OTU, whereas 1.75% were found in all 6 habitats, which however had an average of 1206 reads per OTU, and were thus much more abundant.

In order to determine if each OTU could be considered a habitat specialist or generalist, a niche breadth index was calculated by considering how frequent an OTU is and how evenly its abundances are distributed. We found that very few OTUs could be considered generalists and that these OTUs were not particularly abundant. Despite the largest part of OTUs were clearly specialists, also theses OTUs had rather low abundances. All habitats, except for the sediment, were dominated by OTUs that could not be defined specialist nor generalist and that were found in similar abundances in other habitats, too.

In conclusion, the animal-associated bacteria community was similar, and slightly less diverse then in the surrounding available microenvironments. However, the animal microbiome was not more habitat-specialised then the water or stone microbiomes and OTUs on animals are shared with any other of the habitats.

25-P Distribution of serotonin and the clock protein period in the brain of *Daphnia pulex*. *Piotr Bernatowicz* [1] *- Marta Polańska* [2] *- Piotr Bębas* [2] *- Bohdan Paterczyk* [3]

Dapartment of Paleobiology and Evolution, Faculty of Biology, University of Warsaw, University, Warsaw, Poland [1] *- Department of Animal Physiology, Faculty of Biology, University of Warsaw, University, Warsaw, Poland* [2] *- Laboratory of Electron And Confocal Microscopy, Faculty of Biology, University of Warsaw, Warsaw, Poland* [3]

Recently described biological clock of *Daphnia pulex* consists of molecular oscillator and its input and output pathways. The *D. pulex* oscillator is composed of genes and proteins that seem to be coupled in a form of feedback loops. Period protein (PER) plays the key role in this mechanism.

Serotonin is a biologically active monoamine. It has been described as neurotransmitter involved in the regulation of many physiological functions in crustaceans including these associated with behavioral rhythms.

The aim of our study was to map a connection between groups of clock containing neurons and serotonergic neurons (which constitute at least one of the clock outputs pathways) in *Daphnia* brains.

To reach this goal we characterize PER and serotonin distribution in the brains of *D. pulex* using immunochistochemical method with anti-PER and anti-5HT antibodies followed by tissues analysis in the confocal microscope.

We found PER protein expression only in two neurons of *D. pulex* protocerebrum, while serotonin was identified in six neurons, both in proto- and deutocerebrum. We found no co-localization of PER and serotonin, which were detected always in different populations of neurons. However, nerve endings of both PER and serotonin neurons are localized very close to each other, supporting hypothesis of the synaptic connection between them.

This study was supported by the Polish National Science Centre (NCN) Grant No. 2013/11/B/NZ4/03310 (to Piotr Bebas).

25-P Phylogenetic evidence for a new species of *Barbus* in the Danube River basin. *László Antal* [1] *- Brigitta László* [2] *- Petr Kotlík* [3] *- Attila Mozsár* [4] *- István Czeglédi* [4] *- Miklós Oldal* [5] *- Gábor Kemenesi* [5] *- Ferenc Jakab* [5] *- Sándor Alex Nagy* [1]

Department of Hydrobiology, University of Debrecen, Debrecen, Hungary [1] *- Department of Medical Microbiology, University of Debrecen, Debrecen, Hungary* [2] *- Laboratory of Molecular Ecology, Institute of Animal Physiology And Genetics, The Czech Academy of Sciences, Libechov, Czech Republic* [3] *- Balaton Limnological Institute, MTA Centre for Ecological Research, Tihany, Hungary* [4] *- Virological Research Group, Szentágothai Research Center, University of Pécs, Pécs, Hungary* [5]

Three species of small-sized rheophilic *Barbus* fishes are endemic to and widely distributed throughout the mountain regions in the Danube River basin. In Hungary, barbels referred to as *B. petenyi* occur in streams in the foothills of the Carpathians near the borders with Slovakia, Ukraine and Romania. However, up to now, no genetic investigations were carried out on rheophilic barbels in this region. This study aims to clarify the taxonomic identity and distribution of the rheophilic barbels in the Hungarian plain based on molecular and morphological analyses. Two mitochondrial genes (cytochrome *b*, ATPase 6/8) and one nuclear gene (beta-actin intron 2) were sequenced and several morphometric and meristic characters were recorded. Phylogenetic and morphological analyses revealed that there are four genetically distinct lineages among the rheophilic barbels in the Carpathian Basin. The results demonstrated that North-Hungarian *Barbus* populations belong to *B. carpathicus* and that *B. petenyi* presumably does not occur in Hungary. As expected, *B. balcanicus* was only recorded in samples from the Balkans analyzed for reference. A distinct species, new to science, was discovered to be present in Sebes-Körös River (Crişul Repede) in eastern Hungary and western Romania and is formally described here as Biharian barbel *Barbus biharicus* Antal, László & Kotlík, 2016.

25-P   Phytoplankton cytometric analysis of viability and metabolic activity in the presence of endogenous autofluorescent pigments.   *Veronika Dashkova[1], Dmitry Malashenkov[1], Jeff Clapper[2], Ivan Vorobjev[1], Natasha Barteneva[3]*

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Chlorophyll autofluorescence is an indicator of photosynthetic activity and is widely used for evaluation of living status of phytoplankton by cytometric methods. Phytoplankton is particularly suitable for cytometric analysis due to its microscopic sizes, free living in aqueous environment and presence of endogenous autofluorescent pigments. However, autofluorescence imposes complexities to cytometric analysis by overlapping with emission spectra of traditionally fluorescent dyes used for phytoplankton characterization. In this work, to overcome the influence of strong autofluorescence on fluorescent measurements we used the following approaches: 1) use of dyes with minimal spectral overlap and multi-laser cytometers; 2) imaging cytometry that allows to determine spatial correlation between autofluorescence and our staining and 3) spectral unmixing of dye combinations and algal pigments' autofluorescence by spectral flow cytometry (spectral-FCM).
Using a multicolor imaging cytometer we compared fluorescence of chlorophyll with Sytox Blue, annexin V and calcein AM using *Aphanizomenon sp*. cyanobacteria culture (CCMP2764) and coccolithophore strain *Emiliania huxleyi* (CCMP2090). Samples were analyzed using 5-laser SORP FACSAria flow cytometer (BD Biosciences, San Jose, USA), 5-laser Imagestream X Mark II imaging flow cytometer (Amnis-Millipore Inc, Seattle, USA) and 3-laser SP6800 spectral-FCM (Sony Biotechnology Inc, San Jose, USA). Sytox Blue and Calcein staining unambiguously showed that many dead cells retain strong chlorophyll signal. Imaging cytometry allowed seeing the slightly different pattern of chlorophyll in the dead cells compared to live ones that can be critical for assessment of phytoplankton viability.
Unlike conventional cytometer spectral-FCM allowed us to measure and subtract autofluorescence from each phytoplankton cell across the full spectrum. We used spectral unmixing algorithm to analyze freshwater environmental phytoplankton samples stained with calcein AM in the presence of strong and heterogeneous autofluorescence from intrinsic phytoplankton pigments (chlorophyll, phycoerythrin etc). Spectral-FCM analyzer allowed us robustly identify more than 10 subpopulations in the sample.
We conclude that the multi-color staining of phytoplankton samples and precise analytical capabilities can be achieved in the presence of heterogeneous algal autofluorescence using multi-laser approach, dyes with minimal spectral overlap, spatial parameters (imaging cytometry) and/or spectral unmixing (spectral-FCM).

25-P   Application of a self-organizing map (SOM) to multiple DNA sequence comparison from gut contents of largemouth bass.   *Hyun-Woo Kim [1] - Kwang-Seuk Jeong [2] - Hyunbin Jo [2] - Keon-Young Jeong [2] - Gea-Jae Joo [3]*

Department of Environmental Education, Sunchon National University, Sunchon, Republic of Korea [1] - Institute of Environmental Science & Technology, Pusan National University, Busan, Republic ofKorea [2] - Department of Biological Sciences, Pusan National University, Busan, Republic of Korea [3]

Recent advances in molecular biology, such as DNA barcoding, have facilitated an increase in the efficiency and effectiveness of limnological research. Accurate high-resolution results provide new opportunities for achieving a more in-depth understanding of the structure and function of aquatic ecosystems. The comparison of DNA sequences is perhaps the best strategy for thoroughly understanding ecosystems; however, multiple sequence comparison is often a laborious job. To resolve this issue, we present an efficient method for discovering conserved and variable regions within compared multiple DNA sequences from the gut contents of largemouth bass, using a self-organizing map (SOM). Binary transformation of nominal nucleotide base information was applied to two types of DNA sequence datasets (one was relatively shorter, containing highly intra-specific variation and the other was relatively longer, containing multiple species). Two SOM models were developed for each dataset, and each model processed their respective DNA datasets efficiently. Conserved and variable regions within the given multiple sequences were successfully identified by the data visualization ability of the SOM. Furthermore, the length of the DNA sequences did not adversely affect SOM performance. Similar species with very small nucleotide differences were well recognized and those species ordinated differently onto the SOM plane. The powerful visualization capacity of SOM enabled the screening of different base locations, which may increase the efficiency of species-specific sequence location exploration. We expect that the visualizing ability of SOM will lead to more effective comparisons of DNA sequences across multiple species.

26. LIFE STRATEGIES OF FRESHWATER INVERTEBRATES: COUPLING LIFE HISTORY TRAITS AND FITNESS IN A CHANGING WORLD

26-O   Adaptation of benthic communities to ecopeaking in alpine rivers.   *Maria Cristina Bruno* [1] - *Bruno Maiolini* [2]

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Daily changes in physical and chemical water parameters (i.e., ecopeaking) can occur in defined seasons in natural conditions in kryal , due to the summer daily glacial melt and consequent changes in runoff. Only few and specialized taxa living in such extreme habitats are adapted to such cyclic changes (e.g., Chironomidae Diamesinae and Simuliidae Prosimulinae). In regulated rivers, however, ecopeaking changes are sudden, occur once or more times per day, and span through the entire year, and are related to the releases from hydropower plants fed by high elevation and stratified reservoirs (i.e., hydropeaking). The entire downstream benthic community is affected and, because large hydropower plants are usually at low elevation, they affect communities which are not necessarily adapted to naturally-occurring changes. Hence, the effects of ecopeaking is very relevant. Changes in discharge (hydropeaking) and temperature (thermopeaking) have been proved to cause massive drift responses in benthic invertebrates in field and simulated conditions, whereas changes in turbidity, suspended sediments, conductivity and other chemical parameters have been less investigated.
Rapid growth of the human population and economic development are tightly coupled with an increase in global energy demand, which is causing a current boom in hydropower dam construction (Zarfl et al., 2015). The effects on the biota already are, and will be, dramatic, and need to be fully understood. Simuliidae were selected as target taxon to assess the effect of ecopeaking on larval development and emergence. In fact, Simuliidae larvae are filter feeders, sensitive to alterations of solid transport and temperature and they permanently colonize floating substrates. Hence, they are easy to be semi-quantitatively collected upstream and downstream of the alteration source. Furthermore, the larvae have sclerotized head capsules which can be easily measured to assess life cycle parameters, and the pupal cases and exuviae remain fixed on the substrate after adult emergence and allow identification at the species level.

26-O   Monopolisation hypothesis in freshwater ponds: is the large bank of resting stages the key feature? *Diego Fontaneto*

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An apparent paradox is present in the pattern of distribution of genetic diversity in microscopic freshwater invertebrates. Their high dispersal capacity is in contrast with the genetic differentiation among populations in neighbouring ponds. The 'monopolisation hypothesis', accounting for founder events, local adaptation, and banks of resting stages, is often suggested as the main explanation. Thus, locally adapted genotypes surviving in large number as resting eggs should prevent new incoming genotypes to settle in the pond. Is the presence of resting banks the key point in buffering against incomers? To support this idea I will provide empirical evidence comparing genetic structure of population of phylogenetically related co-occurring rotifers, similar in size, feeding behaviour and reproductive ability, but differing for the production of resting stages. Monogonont rotifers, producing resting eggs, should conform to the hypothesis; on the other hand, bdelloid rotifers, entering dormancy in every moment of their lives and not producing resting eggs, should not conform to it.

26-O   Functional response of communities of the family Chironomidae to deteriorating ecosystems health in an effluent impacted river, Eastern Cape, South Africa.   *Ogehenekaro Nelson Odume*[)]

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Developing simple but efficient and robust biomonitoring tools capable of indicating biotic change and diagnostic of the drivers of such change is crucial for sustainable freshwater resource management and biodiversity protection. Using carefully selected species traits in freshwater biomonitoring can provide mechanistic and adaptive bases for linking biological response to environmental stressors, thus enabling the diagnosis of impact. In this study, a novel chironomid traits-based approach was developed to investigate the functional response of chironomid communities to deteriorating water quality in the Swartkops River, Eastern Cape, South Africa. Chironomid larvae and physico-chemical sampling were undertaken over three years, August 2009 – September 2012, at one upstream control site (i.e. Site 1) and three downstream sites (i.e. Sites 2, 3 and 4) characterised by organic pollution. Chironomid species were grouped into seven functional strategies (i.e. FNSs A – G) according to their body sizes, presence/absence of haemoglobin, preferences for food: detritus, algae, macrophyte and animal parts, and biotopes: stones, vegetation and sediments. The FNS approach developed in this study was sensitive to water quality differences, discriminating between Site 1, and Sites 2, 3 and 4. It was also diagnostic of the main water quality stressors, indicating that dissolved oxygen (DO), electrical conductivity (EC), turbidity and nutrients were the main drivers of the biotic change between the sites. It was concluded that the chironomid FNS approach developed in this paper is a potentially useful biomonitoring tool for sustainable freshwater resource management because in addition to being sensitive to water quality differences, and diagnostic of the main drivers of biotic change, it was predictive of the expected assemblage based on the prevailing environmental conditions at each of the sites.

26-O   Which life strategies facilitate the adaptation of aquatic invertebrates to fine sedimentation?

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In the last decades, human-induced alterations of the natural morpho-hydrological characteristics have altered the transport-deposition cycle in many rivers, so that siltation, i.e. the unnatural accumulation of fine sediments on riverbeds, has become an important ecological problem, particularly in mountainous areas. Fine sediments occlude stream bed interstices, reducing interstitial water exchange, lowering the concentration of dissolved oxygen within the sediment, and altering retention and transformation of organic matter and nutrients. Obviously, fine sediments can have a strong impact on the composition, diversity and distribution of stream invertebrate assemblages, because these organisms use substrata for feeding, shelter, deposition and incubation of eggs, and refuge from physical or hydrological disturbances. In this communication, we report results from different studies realized in Northern Apennines and in the South-Western Alps. Abundance and both taxonomic and functional diversity of aquatic invertebrates generally diminished in clogged substrata, because of different indirect and direct effects. Direct effects can be related for example to the loss of microhabitat and the damage to respiratory systems of organisms. Indirect effects include for example the change of the ecological processes that are on the basis of autochthonous, i.e. abundance and distribution of ephilitic algae, and allochthonous, i.e. retention and availability of terrestrial leaves, sources of energy for the aquatic ecosystem. In this context, we analyzed life strategies, and in particular biological and ecological traits, of stream invertebrates living in environments affected by different level of siltation. The effect of siltation affected organisms belonging to several functional, ecological and biological groups. In particular, collectors-filterers, shredders and scrapers generally reduced their abundances, such as happened for large, semi-voltine, crawlers organisms. Interestingly, only few groups, characterized by rapid development, (especially but not exclusively) short life cycles, deposit feeding and especially burrower habits, tolerated or even benefited from the clogging process. Our study finally highlighted those life strategies that enhance a greater adaptability to clogging. Based on these data, we could predict how biological communities will vary in those sites that will be affected by increased fine sedimentation in the future.

26-O   Do benthic invertebrates eat what we think? A gut content and stoichiometric analysis.

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A still common assumption in the ecological studies of rivers is that benthic macroinvertebrates are assigned to specific functional trophic groups and, therefore, feed on the same resources whatever the population. Although there is increasing awareness on substantial variations in the diet of consumers, the specific reasons are not yet completely clear. In this study we first test the general hypothesis that there are significant differences in the diet of particular benthic macroinvertebrates. This objective was pursued by comparing the gut contents of several macroinvertebrate taxa representatives of the major functional feeding groups (i.e. predators, shredders, collector-filterers, collector-gatherers, scrapers) in three sampling stations of a Mediterranean mountain river in Sierra Nevada, Spain. With this information, we estimated the quality of the consumed resource for each macroinvertebrate as the difference (i.e. elemental imbalance) between consumer's C:nutrient ratio and the weighted C:nutrient average of the consumed resource. Our results support the hypothesis that macroinvertebrate diet varies among sampling sites, and across the life history of the organism. In addition, according to ecological stoichiometry predictions we found strong differences in the elemental composition across benthic macroinvertebrates, whereas within-taxa variations were much more restricted. In contrast, the elemental composition of their resources was more variable and ranked from lowest to highest food quality, course particulate organic matter, fine particulate organic matter, epiliton and macroinvertebrates. Implications of these results with regards to macroinvertebrate categorization into fixed functional feeding groups, fitness and susceptibility to nutrient limitation are discussed.

26-O   Lifecycle adaptation of freshwater invertebrates to global warming.   *Mayumi Yoshimura*

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Global average surface temperature has rose by 0.74°C over the period 1906-2005. Climate model projections summarized in the IPCC Fourth Assessment Report (AR4): Climate Change 2007 that the global surface temperature would increase a further 1.8 - 4.0 °C in 2100. Warming global temperature will lead droughts, heavy rainfall with floods and heavy snowfall, and then it will result in the extinction of many species and the reduced diversity of ecosystems. Global warming is a critical factor for freshwater invertebrates that inhabit cooler freshwater stream. After the last glacial period, freshwater invertebrate species that inhabit cooler streams had been constrained to thrust to the higher mountain areas because of the increasing water temperature. So, global warming will let them thrust to further higher area and will lead the reduction of their habitat. Otherwise, they might struggle to adjust their life cycle: egg-larval-adult periods, egg-larval-adult maturation and reproduction. Adaptation of freshwater invertebrates to the global warming and the change of the freshwater invertebrate assemblage will be discussed.

26-O   Reconstructing the evolution of antioxidant defense mechanisms and ageing patterns: *Daphnia* coping with changing stressors.   *Sarah Oexle* [1] - *Mieke Jansen* [1] - *Kevin Pauwels* [1] - *Ruben Sommaruga* [2] - *Luc De Meester* [1] - *Robby Stoks* [1]

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Natural populations can cope with rapid changes in environmental stressors by relying on sets of physiological defense mechanisms. Little is known onto what extent these physiological responses reflect plasticity and/or genetic adaptation, evolve in the same direction, result in an increased defense ability and influence life history traits. Using resurrection ecology, we studied in a first experiment how a natural *Daphnia magna* population adjusted its antioxidant defense to ultraviolet radiation (UVR) during a period with differing incident UVR reaching the water surface. Here we demonstrate rapid evolution of the induction patterns of key antioxidant enzymes under UVR exposure in the laboratory. Notably, evolutionary changes strongly differed among enzymes and mainly involved the evolution of UV-induced plasticity. These differentially evolved antioxidant strategies were collectively equally effective in dealing with oxidative stress since they resulted in the same high levels of oxidative damage and lowered fitness under UVR exposure. The lack of better protection against UVR may suggest that the natural UVR exposure in the water did not increase between both periods. What may have contributed to the evolved defense strategy is the predator-induced evolution to migrate to lower depths that occurred during the same period. We therefore tested in a second experiment with the same populations whether strong changes in fish predation pressure resulted in evolutionary changes in ageing. While the classic theories of ageing predict accelerated ageing under higher extrinsic mortality, it is still under considerable debate

whether and how predation drives the evolution of ageing. Despite previous work showing life history evolution driven by changes in predation pressure in this population, we did not detect evolution of ageing rates neither in lifespan nor in fecundity. The absence of support for the classic evolutionary theories of ageing may be explained by density- and condition-dependent processes operating under high fish predation pressure.

26-O   The habitat templet concept revisited: understanding interspecific variation of life-history strategies in aquatic insects of semiarid regions.

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According to Southwood's templet concept, the characteristics of habitat (in terms of its variability in space and time) are the template shaping the evolution of species' life history strategies. Based on this concept, we propose a framework for understanding variation in species' life-history strategies of aquatic insects in inland waters of arid and semiarid climatic regions. The temporal dimension of the template is defined by the stability and persistence of habitat at geological and ecological scales, assuming that lentic habitats (standing waters) are generally short-lived and experience greater variability in environmental conditions than lotic (running waters) habitats. The spatial dimension is represented by heterogeneity in water salinity, one of the main environmental filters in aquatic systems of arid zones worldwide, and its interactions with other environmental factors, such as water ionic composition and temperature. In this framework, colonization capacity given by physiological tolerances and/or dispersal ability are expected to increase from lotic-freshwater to lentic-saline species as habitat conditions become more adverse and instable. To test these predictions, we summarized data obtained from 2010 to date from ecophysiological studies in three families of water beetles (Dytiscidae, Hydrophilidae and Hydraenidae) and one family of water bugs (Corixidae) with representative species of lotic and lentic habitats along a salinity gradient. We studied several traits related to tolerance to salinity, temperature and desiccation, and flight dispersal ability. We compared these traits among congener species showing habitat specificity for lotic and lentic waters and along a salinity gradient. As expected, lentic species showed in general greater salinity and thermal tolerance ranges, better flight ability and lower sensibility to acute thermal and saline stress than lotic ones. Consequently, behavioral responses to avoid acute stress were higher or initiated at lower stress thresholds in lotic than lentic species. In contrast, desiccation resistance was more related to the osmoregulation capacity of the species than habitat type, being the saline species in general more resistant to desiccation that freshwater ones. Regarding the interaction of salinity with anionic water composition, sulphate rich water decreased the species' salinity tolerance. The interaction of salinity with temperature had differential effects on species´ thermal limits. In some species, acclimation at high salinities and temperatures decreased their heat tolerance, while in most of the more saline-tolerant species the inverse pattern occurred. Our results are in general agreement with the habitat templet framework proposed suggesting that in the case of aquatic insects of arid regions, species in lotic habitats, and especially those restricted to freshwaters, could be more vulnerable to future environmental changes than their lentic relatives.

26-O   Testing cross-resistance to desiccation and salinity in two Iberian endemic saline water beetles.

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Exposure to stressful conditions may confer organisms resistance to other stressors (*cross-resistance*), but may also result in trade-offs with other traits if the energetic costs of such adjustment overtake physiological benefits. Insects living in inland saline waters from Mediterranean climate regions, characterized by seasonal dry and wet periods, face episodic events of desiccation stress together with other permanent stressors such as high salinity. Therefore, selection for plastic responses to desiccation and salinity could be favored in these habitats.
We designed a set of experiments to identify cross-resistance to desiccation and salinity - two factors entailing hydric and osmotic stress on organisms. We used adults of two Iberian endemic hypersaline water beetles, *Enochrus jesusarribasi* (Hydrophilidae) and *Nebrioporus baeticus* (Dytiscidae), to test the effects of: 1) hardening (short-exposure)

at two non-lethal desiccation conditions on the subsequent tolerance to a high salinity and 2) acclimation (long exposure) at a stressful salinity on the subsequent resistance to desiccation. We measured survival and key traits related to osmoregulation and water balance in insects (% water content, % water loss rate and osmotic capacity).

Desiccation pre-treatments decreased survival under a subsequent exposure to a high salinity in both species. The percentage of water loss during desiccation rather than the desiccation rate or the osmotic concentration of the haemolymph seemed to explain this reduction in individuals' fitness. Therefore, the desiccation conditions tested here appear to cause a non-reversible dysfunction of osmoregulation and water balance mechanisms, resulting in a trade-off with salinity tolerance.

In contrast, acclimation at a stressful salinity increased survival under a subsequent desiccation exposure in *N. baeticus* by reducing its water loss rate, and increased the water content of *E. jesusarribasi* with a neutral effect on survival. These results suggest that hyporegulation mechanisms during salinity exposure improve water conservation efficiency in both species and point out that desiccation and salinity tolerances are governed by at least partially common physiological mechanisms. The differences in basal desiccation resistance and physiological plasticity of desiccation traits found here between the species might reflect the different evolutionary history of each lineage, but could also be related to their different osmoregulatory capacity, microhabitat occupation or potential for behavior plasticity. Our results provide an essential scaffold to our understanding of the evolution of salinity tolerance in water beetles but also offer important information for the estimation of aquatic species vulnerability to climate change.

26-O   Niche overlap between two congeneric dragonflies at their range margins.   *Martina Dalle* [1] - *Elena Piano* [1] - *Stefano Mammola* [1] - *Elisa Riservato* [2] - *Francesca Bona* [1] - *Marco Isaia* [1]

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According to the central-marginal hypothesis, populations become smaller and scarcer towards their range margins, since survival and growth decrease at increasing distance from the environmental optimum. Therefore, smaller populations at the range margins are more prone to extinction due to stochastic events and to genetic drift. Moreover, for many invertebrates with restricted dispersal mechanisms, peripheral populations represent leading edge populations in the ecological response to environmental change. In this respect, the assessment of the ecological preferences for the peripheral populations is an important challenge, especially in the current global climate change scenario. In recent years, growing attention has been given to the conservation of invertebrates, in particular aquatic insects, which are expected to suffer high extinction risks. In this study, we focus on peripheral populations of *A. grandis*, classified as Vulnerable according to the Italian Red List, in coexistence with *A. juncea* (Odonata, Aeshnidae) aiming to investigate ecological niche partitioning at the local scale. In particular, we focus on the environmental features favoring the presence of both *A. grandis* and *A. juncea* at the microhabitat level with particular reference on how the two species avoid competition. We studied three populations in three different lakes in Valtournenche (Aosta Valley, NW-Italy) over two years (2013-2014). Presence data of exuviae were gathered from ca. 50 sampling plots per lake in the summer season at the peak of emergence of adults. During the sampling sessions, we measured several environmental variables referring to water, vegetation and light conditions at each sampling plot. Abundance of exuviae was related to the different environmental variables via GLMM procedures. Moreover, we assessed the competition between the two species, using novel n-dimensional hypervolume statistical techniques. The results of GLMMs showed water cover (intended as the percentage of the plot free from vegetation) to significantly influence the abundance of the two species with a differentiated effect. Specifically, *A. grandis* increased significantly at intermediate values while *A. juncea* preferred plots with lower water cover. As confirmed by the niche hypervolume analysis, water cover emerged as the most important environmental factor driving the segregation of the two species. In addition, the niche of both species resulted influenced by vegetation structure, namely vegetation height for *A. juncea* and floating macrophyte cover for *A. grandis*. Finally, we underline how the coexistence of congeneric species is enhanced by the environmental differentiation at local level, which represents a key factor in the conservation of the ecosystem biodiversity.

26-O   Adaptations in a freshwater shrimp (*Gammarus pulex*) to increased salinity: which responses boost survival? *Elisabeth I. Meyer, Berit Philipp, Deula Santhosh Kumar, Alexander Schmidt-Drewello, H. Wolfgang Riss*

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Increased salinity of inland waters directly or indirectly has an effect on benthic communities, by influencing the behaviour as well as the physiology of the organisms. In a comparative study, we investigated traits and adaptations of the freshwater shrimp *Gammarus pulex* from two confluent streams with different salinity levels, situated in undulating lowland of northwest Germany - Central Europe (Saltwater Creek SWC: 6.0 to 7.5 g/L NaCl, Freshwater Creek FCW: approx. 0.3 g/L NaCl). In the SWC, *G. pulex* lives in the fringe range of physiological tolerance described for the species. The study targeted the mechanism that allows *G. pulex*, using with salinity as a case example, for extension of its distribution range along an environmental gradient and outlasting of extreme physiological conditions.

Between 2012 and 2015, macrozoobenthic communities were sampled semi-quantitatively (based on area-time-reference), and abiotic environmental variables were recorded during each sampling campaign. In laboratory analyses, *G pulex* populations were tested for morphological parameters and age structure, physical performance, glycogen contents, and as a measure of stress response for hsp70-expression at a 27°C heat shock.

G. pulex dominates in both benthic communities with SWC harbouring a significantly poorer and uneven taxa diversity compared to FWC. Contrarily thereto, *G. pulex* found in SWC represents a stable population. Morphological and experimental analyses revealed that *G. pulex* from the SWC showed a complex combination of ecological and physiological traits, with differences to FWC individuals being predominantly significant: females have a lower body weight, yet physical activity of both sexes is higher in saltwater gammarids, but also decreases faster during keeping time of one month. At the same time, mortality raises notably. Short-term energy storage, determined by glycogen content, is greater, and base level of hsp70 as well as intensity of expression following heat induced stress is markedly more intense. Based on these findings, we conclude that *G. pulex* tolerates elevated salinity levels by boosting metabolic turnover which apparently only can be maintained under natural conditions of relative system steadiness and availability of resources.

Questions to what extent these mechanisms explain specific salinity tolerance of *G. pulex*, or whether the response pattern found mirrors a general potential of euryoeciousness and thus invasiveness, should motivate further specific investigations.

26-O   The productivity of the macroinvertebrate prey of the platypus in the upper Shoalhaven River, New South Wales, Australia.   *Richard Marchant* [1] *- Tom Grant* [2]

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The platypus, *Ornithorhynchus anatinus*, feeds almost exclusively on benthic macroinvertebrates, yet no attempt has been made to link its energy demands with the productivity of its benthic macroinvertebrate prey. In the upper Shoalhaven River, southern New South Wales, we estimated macroinvertebrate production (in 2009 and 2011) from benthic samples and recorded platypus diet (2009 only) from cheek pouch samples. Ephemeroptera, Trichoptera and Chironomidae were the most numerous of 6 major groups in both the cheek pouches and the benthic samples. Three other groups (Odonata, Coleoptera, Sphaeriidae) were much less abundant in the benthos, but Odonata were common in the cheek pouches. In both years the Ephemeroptera, Trichoptera and Chironomidae had levels of production that were an order of magnitude higher than those of the three other groups. Rank correlation indicated that the most productive taxa were those most likely to occur in the cheek pouches, indicating the platypus did not select its prey. Total macroinvertebrate production for the six groups varied from 7.8 (in 2009) to 13.1 (in 2011) g dry weight per square meter per year. Previous estimates of field metabolic demand of the platypus enabled calculation of the number that could be supported by a given level of production. The observed levels of production were sufficient to support 13-27 platypuses in 2009 and 22-45 in 2011 along a 1.5km reach of the river. Despite considerable landscape change, productive foraging habitat for the platypus persists in rivers of southern New South Wales.

26-O   Status quo of knowledges on Italian high altitude lacustrine macroinvertebrates.   *Matteo Ruocco* [1] *- Ivano Ansaloni* [1] *- Daniela Prevedelli* [1] *- Silvia Zaupa* [2] *- Angela Boggero* [2]

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High altitude lakes and their fauna are one of the most threatened and less investigated ecosystems in Italy. Alpine lakes are highly influenced by climate harshness and by air pollution, and because of their small dimensions are extremely vulnerable to global climate warming. Italy, in addition to the Alps, hosts another mountain range: the Apennines, reaching in some cases comparable altitudes, and therefore subject to the same risks. Moreover, the gentler slope of the Apennines makes them extremely vulnerable even to direct human impacts. In the present work, for the first time, high altitude lakes belonging to the Alps and to the Apennines are compared to highlight which meteo-climatic or chemical characteristics could be considered key drivers for their macroinvertebrate structure. The study area was explicitly focused on natural lakes placed above 1300 m of altitude and above the 44° parallel, thus in the alpine area and subject to a continental climate. 25 lakes were chosen (19 in the central-western Alps and 6 in the Modenese Apennines) with surface areas lower than 1 km^2 and with maximum depths lower than 15 m. Physico-chemical parameters and macroinvertebrates were studied and compared. Samples were taken through the use of a hand-net (250 µm mesh size) along the littorals on different substrates following standardised methodologies during the richer-fauna season to allow an easier identification of species. Parallel to that, water samples were collected and analysed. Species richness and the Taxonomic Distinctness Indices were applied to underline the different complexity of the community structure of the two areas. Results showed different macroinvertebrates communities with peculiar characteristics and highlighted a more structured and diverse composition on the Apennines. Predictive models on the future climate scenarios show how the peninsular portion of Italy will be even more affected by the increase in temperatures than the Alpine area. Thus, this work could be highly informative, mainly for central Italy, where proximity to towns encourage tourists to reach these type of lakes, even if placed in protected areas or parks. Therefore, protection and management plans, and conservation efforts of high altitudes cannot overlooked a thorough understanding of the biological diversity of these environments, which still appears fragmented and limited to some sector of the Alps. Furthermore, the fundamental role of high altitude lakes as water resource needs a specific management regime, as they are not included under the monitoring programs of the Water Framework Directive legislation.

26-P   Life strategies of stoneflies (Insecta, Plecoptera) inhabiting temporary streams of Sierra Morena (Southern Spain). Ten years of studies.   *José Manuel Tierno de Figueroa* [1] - *Ezequiel Antorán-Pilar* [1] - *Pilar Delgado-Juan* [1] - *Julio Miguel Luzón-Ortega* [1] - *Manuel Jesús López-Rodríguez* [2]

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The Mediterranean region is characterized by a marked climatic seasonality with a cold, wet season followed by a warm, dry season. Thus, temporary streams appear conspicuously in this area, which follow a sequence of regular flooding and drying periods. Our studies made during the last ten years on life histories of stoneflies from Sierra Morena (Southern Iberian Peninsula) have shown the existence of particular adaptations to cope with the characteristic of these Mediterranean, temporary streams. We have selected some examples, several of them previously published and some yet unpublished, for underlining many of these biological traits: 1) nymphs of some species show exceptional feeding habits not common for their families (demonstrated both by the study of gut contents and by analyses of digestive enzymatic activities). Thus, due to resource limited availability in temporary streams some stoneflies that usually acts as predators can behave as mainly phytophagous (e.g. *Isoperla morenica*); 2) flight periods are particularly short (for spring species, e.g. *Hemimelaena flaviventris*) or long (for autumn/winter taxa, e.g. *Tyrrhenoleuctra minuta*), almost lacking species with mid-duration flight periods, which are the most common in permanent streams from Southern Iberian Peninsula. This fact can be considered as an adaptation to the limited time in which streams have water; 3) for the same reason, nymphal development is particularly fast, sometimes lasting only a few months (e.g. *Capnioneura gelesae*, *T. minuta*), and resting stages (quiescence or diapause, both in the egg or nymphal stage) can be present during the periods when streams are dry (e.g. *Guadalgenus franzi*); 4) likewise, egg development can be very fast, even the eggs of one taxa, *T. minuta*, are fully developed when laid and hatch rapidly after laying, indicating a certain degree of ovoviviparism; 5) asynchronous nymphal and egg development are usual (e.g. *C. gelesae*, *T. minuta*), which is reflected in several cohorts coexisting at the same time. This ensures the survival of at least part of the population when delays or advancements in the period of drought happen; 6) stoneflies with a spring flight period use to have high secondary production (e.g. *G. franzi*, *H. flaviventris*) reaching relatively big size in a short period of time; 7) nymphs of species inhabiting temporary streams (e.g. *G. franzi*, *I. morenica*) show an important enzymatic antioxidant potential, consistent with data on high population densities and secondary production values. On the basis of these characteristics, it seems

that Plecoptera have sufficient variability in behavioural, ecological and physiological mechanisms to cope with potentially unfavourable conditions that may occur in temporary waters.

26-P   Bio-ecological traits more than taxonomy explain benthic invertebrate response to combined effects of organic detritus availability and fine sediments: an experimental study in the Po River.

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Benthic invertebrate diversity and abundance are greatly influenced by physical template and trophic availability, with responses that could be based more on functional and life-history than on taxonomic features. Unfortunately, many low order lotic systems are increasingly affected by severe morphological and hydrological alterations, due to local (e.g. increase of small and medium-sized dams, hydroelectric plants, logging, etc.) and regional/global (e.g. climate change and in particular increase in hydrological extremes) phenomena, with repercussions on riverine ecosystem (i.e. increased siltation, reduced allochthonous organic inputs). However, the impacts of these alterations on aquatic biota are still largely unknown. In this study we investigated the combined effects of substrate siltation and coarse particulate organic matter availability on benthic invertebrate community in a heterotrophic, Alpine stream in NW Italy. In November 2015, we randomly placed 135 traps in a large and homogeneous reach of the Po river (730 m a.s.l., Paesana, Parco del Monviso), characterized by pristine conditions and coarse river bottom. Each trap consisted of a box built with metal net (5 cm long, 5 cm wide and 15 cm high), with a 1 cm mesh width allowing access for macroinvertebrates. We built up an experimental design with three siltation levels (Coarse traps, filled with gravel; Medium traps, containing 50% gravel and 50% sand; Clogged traps, with 33.3% gravel and 66.6 % sand) and three CPOM amounts (No CPOM; 1 g; 5 g). CPOM consisted in beech fallen leaves collected in the same catchment. Traps were buried into the streambed such that their tops were flush with the bottom. In this poster we illustrate some preliminary findings. We detected evident influences of both siltation and allochthonous detritus level, and of their combined effect, on macroinvertebrate colonizing assemblages. At the first removal date, the highest rate of colonization was reached in traps with intermediate and coarse particle size and highest amount of CPOM, whilst the least colonized were the clogged traps, whatever the amount of organic detritus. Interestingly, we detected that different fine sediments/CPOM combinations were colonized by assemblages that differed more in their biological and ecological characteristics rather than in their taxonomic composition. For example, the siltation level affects interstice size and abundance, with important repercussions on the invertebrate body size and movements. Moreover, the abundance of monovoltine, medium sized, crawler and shredder invertebrates with aquatic respiration was higher in medium to coarse environments and abundant CPOM, while few organisms, mostly microphagous deposit-feeders and burrowers, preferred clogged rather than coarse substrata, independently from organic detritus availability.

26-P   Associations between macroinvertebrates and *Paralemanea mexicana*, an endemic freshwater red algae from mountain river in Central Mexico.   *Angela Caro Borrero, Javier Carmona Jiménez*

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Macrophytes are common inhabitants of lotic environments, and depending on their morphological traits, possess adaptations that provide shelter to aquatic invertebrates against strong river flow and predators. Lotic freshwater red algae grow under very specific conditions and, in general, they lack adaptations such as resting or dispersal cells that would allow them to spread over large ranges. This can limit their role as abundant and frequent taxa in a region. Taking into account the empirical evidence described in the literature, we assume that when the local environmental conditions allow the establishment of any given algae species, it usually forms conspicuous and abundant growths, and significantly contributes to habitat heterogeneity and serves as a macroinvertebrate food source and/or shelter. The main goal of this study was to determine the relationship between the red alga *Paralemanea mexicana* and its role as a shelter and/or food source for lotic macroinvertebrates. We also conducted research on the role of microhabitat and morphological variations of the alga in determining macroinvertebrate taxa abundance, diversity, and functional group composition in a high current velocity river. Results showed that changes in cover and morphology of *P. mexicana* were

mostly correlated with river current velocity, irradiance and seasonal variation. In turn, these were related to changes in abundance and diversity of the associated macroinvertebrate community. In addition, six macroinvertebrate functional feeding groups were evaluated for associations with the red alga: filtering and gathering collectors, piercers, scrapers herbivore shredders, and predators. The results showed that the Trichoptera Hydroptilidae genera *Ochrotrichia* and *Metrichia* use *P. mexicana* as a food source and case building material. The Trichoptera Glossosomatidae *Mortonella* uses the alga as a substrate. The biotic interactions between *P. mexicana* and associated macroinvertebrates reveal the importance of macrophytes as purveyors of substrate, food, and shelter for macroinvertebrates and also as promoters of macroinvertebrate community diversity. In addition, it was shown that macroinvertebrate herbivory likely facilitates vegetative propagation of the red alga through increased release and germination of carpospores and new gametophytes. Finally, the interspecific facilitation is an ecological mechanism that can promote the efficiency of resource use and persistence in stressful conditions in *P. mexicana* and its associated macroinvertebrate assemblages. Nevertheless, these associations may not have been as common in the study area because it is restricted to an isolated geographic region with particular microhabitat conditions. The latter suggests that special morphological traits and interactions promote evolutionary adaptations to successfully compete with other lotic macrophytic species in similar tropical mountain rivers.

26-P   Metabolic and reproductive plasticity of core and marginal populations of the eurythermic saline water bug *Sigara selecta* (Hemiptera: Corixidae) in a climatic change context.

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Ongoing climate change is driving dramatic range shifts in diverse taxa worldwide, and species responses to global change are likely to be determined largely by population responses at their geographical range margins. Here we investigate phenotypic plasticity in metabolic and reproductive traits in two populations of the eurythermic saline water bug *Sigara selecta* from a population located close to the northern edge of its distribution, in a relatively cold, thermally stable region (SE England – 'marginal'), and a population close to the range centre, in a warmer and more thermally variable Mediterranean climate (SE Spain – 'core'). We compared metabolic and oviposition rates and egg size, following acclimation at four different combinations of temperature and salinity. Oviposition rate was significantly higher in the marginal population, although eggs laid were smaller overall. However, no significant differences in oxygen consumption rates were found between core and marginal populations, although the marginal population showed higher levels of plasticity in both metabolic and reproductive traits. Our results suggest that population-specific responses to environmental change are complex and may be mediated by differences in phenotypic plasticity. In *S. selecta*, the higher plasticity of the marginal population may facilitate both its persistence in current habitats and northward expansion with future climatic warming. In contrast the core population was less plastic and may be able to buffer current environmental variability with minor changes in metabolism and fecundity, but could be more prone to extinction if temperature and salinity changes exceed physiological tolerance limits in the future.

26-P   Water quality assessment by benthic bio-indicator, case study: upper basin of Jajrood River, Central Iran.

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In the present study, the benthic Macroinvertebrates were used to determine water quality in upper catchment of Latian dam's reservoir. For this approach, seven stations were determined and river samples were taken in seasonal for min order to determine some of the physical, chemical and microbial parameters, including water temperature, dissolved oxygen, flow, pH, BOD, TDS, TSS, electrical conductivity (EC), PO4, NH4, NO3, NO2, and also coliform and benthic invertebrates used as biological indicators of environmental. Three samples were taken at each station and benthic Macroinvertebrates were isolated and counted in the laboratory. Using population structure data, benthic

Macroinvertebrates metrics are computed by using biological indicators Hilsenhoff at the Family level (HFBI), index BMWP/ASPT, indicator signal, Trent Biological Index (TBI) and BBI Index and Multimetric Macroinvertebrate Index Flanders and IBI and NJIS, water quality assessment and interpretation were compared with the results of chemical indicator. The results showed that Chironomidae has the most abundance in the studied region and biological indicators Hilsenhoff, BMWP/ASPT, Signal and Trent Biological Indexes (TBI) are useful Biological indicators for the assessment of Jajrud water quality. It is necessary to perform needed compatibility and calibration based on geographical and physicochemical conditions of Iran's rivers to efficient use of multi-metric indicators.

26-P Functional traits and life-history strategies in water quality biomonitoring and assessment.

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Currently, about 300 different methods are used in Europe to assess water quality under the Water Framework Directive (WFD). To compare comparison of water quality between countries, a harmonization of assessment approaches and concepts is required. Project Waterscan from Naturalis Biodiversity Center aims to contribute by developing a new macroinvertebrate biomonitoring tool suitable to address current (and future) issues in freshwater quality assessment. Most water assessment methods grade water quality, but do not show which environmental variable is responsible for a low WFD score. Adding a diagnosis of why a waterbody has a certain water quality is an important improvement to freshwater biomonitoring. Such diagnosis can be achieved by integrating functional traits into life-history strategies and linking these to important environmental variables.

Many environmental factors (both biotic and abiotic) play a key role in structuring macroinvertebrate communities; flow regime and habitat quality for example. However, determining exactly which environmental variables are vital to include in a biomonitoring tool remains difficult. A solution can be found in the concept of 'ecological key factors': a set of several variables that together explain most of the macroinvertebrate occurrence. These key factors are ecological in the sense that they are *directly* relevant for the occurrence and survival of macroinvertebrates, such as dissolved oxygen concentrations and water pH levels. As part of the Waterscan project a small set of ecological key factors is being composed, including a hierarchal structure of which factors weigh more heavily in shaping macroinvertebrate communities. The key factors are selected based on literature, expert opinion and statistical analysis of databases on macroinvertebrate occurrence and environmental variables.

The direct action of environmental factors affects organisms through their functional traits. Different species have different combinations of traits, or life-history strategies, allowing them to survive under different environmental circumstances. This makes certain life-history strategies indicative of specific environmental conditions, allowing for biomonitoring of environmental variables. Using existing data on macroinvertebrate occurrence, environmental variables and traits, the traits and strategies that link species occurrence to ecological key factors are analyzed.

This study is focused on a single water typology, peat fenns, and uses data on two taxa, Trichoptera and Coleoptera. The outcome of this analysis forms the basis for a multimetric approach to water quality assessment. An ecological framework will be presented that may serve as the foundation of a new biomonitoring tool for assessing water quality, based on ecological key factors to detect important environmental stressors using freshwater macroinvertebrates in a life-history trait-based approach.

26-P Fixed and inducible variation in resource allocation patterns in *Daphnia magna* from fish-inhabited and fishless habitats. *Joanna Tałanda, Mirosław Ślusarczyk, Piotr Dawidowicz*

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The presence of fish kairomones induces shifts in resource allocation patterns in *Daphnia*, namely reduces somatic growth and, consequently, body size at first reproduction (SFR), but increases egg number. These changes are considered adaptive, as they likely increase reproductive success of *Daphnia* exposed to size-selective fish predators.

In laboratory experiment we studied the life-history responses to fish kairomones in *Daphnia magna* females isolated from two populations, one inhabiting fish-free pond and the other - a lake where fish were present. Regardless the kairomones presence or absence the lake *D. magna* matured at smaller size and produced more eggs than the pond

Daphnia. In both populations, the exposure to the kairomones presence led to increase in reproductive effort (clutch size), at cost of reduced SFR. However, the kairomone-induced increment in egg number did not depend on animal body size in pond-originated clones, while it was growing with body size of the lake *Daphnia*. This may suggest that egg production at first reproduction is constrained by Daphnia body size in the lake population, while it is not in the fishless pond population.

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27. TEMPERATURE AND CIRCULATION DYNAMICS IN LAKES AND RIVERS

27-O   Long-term warming of the world's large lakes: results from the global lake temperature collaboration.   _John Lenters_ [1] - _Jordan Read_ [2] - _Sapna Sharma_ [3] - _Catherine O'Reilly_ [4] - _Stephanie Hampton_ [5] - _Derek Gray_ [6] - _Peter McIntyre_ [7] - _Simon Hook_ [8] - _Philipp Schneider_ [9] - _GLTC Contributors_ [1]

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Recent studies have shown significant warming of inland water bodies around the world. To better understand the patterns, mechanisms, and ecological implications of global warming of lakes and reservoirs, the "Global Lake Temperature Collaboration" (GLTC) was initiated in 2010 to compile and analyze inland water temperature data from in situ and satellite-based records dating back at least 20-30 years. The GLTC project has now assembled data from over 250 lakes, with some records dating back more than 100 years. Here, we present an analysis of the long-term warming trends, interdecadal variability, and a direct comparison between in situ and remotely sensed summer lake surface temperatures. The results show consistent trends of lake surface warming across most but not all sites. A few hotspots of warming are identified around the world, including the Laurentian Great Lakes, northern Europe, and southwest United States. Almost half of the world's lake surfaces are warming at rates in excess of 0.5 °C per decade during the period 1985-2009, and a few even exceed 1.0 °C per decade. This is particularly true for a number of the world's large, deep lakes, and we discuss some of the mechanisms responsible for this counterintuitive result.

27-O   Seasonal patterns of surface temperature for 732 lakes across the globe: can these be used to define freshwater biomes?   _Stephen Maberly_ [1] - _Ruth O'Donnell_ [2] - _Mark Cutler_ [3] - _Ian Jones_ [1] - _Christopher Merchant_ [4] - _Claire Miller_ [2] - _Eirini Politi_ [3] - _Marian Scott_ [2] - _Stephen Thackeray_ [1] - _Andrew Tyler_ [5]

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Remote sensing has the potential to yield a synoptic assessment of the surface state of lakes around the world. The UK NERC-funded project GloboLakes, has analysed surface temperature records from 732 lakes over the globe for 14 complete years between 1997 and 2012 based on information from the series of Along-Track Scanning Radiometers (satellite-borne sensors) produced as part of the ESA-funded ARC-Lake Project. Functional clustering analysis was used to group the lake responses. In this approach, the observed time series data for each lake are smoothed using a b-spline basis to remove local variability and to create lake mean curves. Subsequently k-means clustering was applied to the basis coefficients which define the smooth curves. A data-driven approach was used to select the statistically optimal number of clusters. For each lake, the distance from the lake mean curve to each of the cluster means was used as a proxy for certainty in classification.
The lakes were split into eleven clusters of between 19 and 180 lakes which were each internally similar in terms of the form, phase and amplitude of their annual temperature cycle and their annual mean temperature. The lake clusters mapped onto the globe in clear patterns that were related to geographical factors including latitude, elevation and longitude. Terrestrial vegetation is often classified into biomes based on climate, particularly temperature and precipitation. Because of the pervasive effect of lake temperature on the structure and function of lakes, we discuss whether or not lake biomes might also be recognised based on this approach or whether the character of a lake, such as its lake morphometry and bathymetry, or the effect of local factors such as nutrient load, might override the effects of large scale climate that controls lake temperature.

27-O The simulated impact of increased frequency of extreme climatic conditions on a sub-tropical lake ecosystem. *Gideon Gal* [1] *- Dirk Scbling* [2] *- Yael Gilboa* [3] *- Noam Shachar* [1]

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Changes in climatic conditions are occurring and are predicted to intensify into the future thereby affecting lake water temperatures and thermal dynamics. As water temperature affects a wide range of physical, chemical, and biological processes in lakes understanding possible future changes is critical to predicting potential ecosystem changes. Typical outputs of climate change models include moderate, monotonic, long-term changes to weather conditions. When these conditions are applied to lake ecosystem models they often do not have a significant impact on the ecosystem. In addition, recent historical data from various locations around the world suggest an increase in the frequency of extreme events as a result of global climate change. Recent climatic conditions in Israel, for example, show only a moderate change in mean conditions but an increased frequency of extreme conditions and events. In order to examine the impact of changes to the frequency of extreme events on the Lake Kinneret ecosystem, we conducted ensemble modeling of the effect of climate changes on the lake. We did so by combining a Vector-Autoregressive Weather Generator (VG) and two 1D lake hydrodynamic models. We examined the impact by conducting numerous long-term scenarios which differed in the frequency of extreme events that occurred over periods of 20 years. We studied the impact on water temperature and thermal stratification dynamics. Results indicate that the combined impact of moderate monotonic changes in climatic conditions along with an increased frequency of heat waves had the largest impact. Impacts included not only changes in mean and maximum water temperature but also in the extent of the stratification period. These changes are very likely to impact the ecosystem including key biological and chemical processes increasing the probability of larger and longer periods of cyanobacteria blooms in the lake.

27-O Impact of extreme climatic events on metabolism of Lake Eymir using real-time automatic lake observation station. *Duygu Tolunay* [1] *- Ali Serhan Çağan* [1] *- Rojda Duygu Ögel* [2] *- Nusret Karakaya* [2] *- Fatih Evrendilek* [2] *- Meryem Beklioğlu* [1]

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In this study, real-time high frequency automatic lake motoring system is used to calculate lake metabolism for Lake Eymir where is located in cold-dry steppe climate. The automated system consist of two sondes, 7 temperature probes and meteorological station. First sonde at 1.5m measures pH, ORP (oxidation-reduction potential), fDOM (fluorescent dissolved organic matter), DO (dissolved oxygen), chl-a (chlorophyll-a), BGA (blue-green algae), turbidity, temperature, TDS (total dissolved solids), conductivity and salinity. Second automated system is located at 4 meter and measures temperature, TDS, chl-a, conductivity, salinity, pH and DO. Throughout the study, there were severe drought in summer with cyanobacteria blooms in summer, and extreme flooding with instant mixing of Lake Eymir during end of summer caused anoxic conditions with fish kills. In this study, we analyzed the impact of such extreme events for lake metabolisms. Such extreme events are anticipated to be more intense and frequent in future. We will discuss thoroughly how lake metabolisms responds to such extreme events to be able to suggest better restoration measures.

27-O Simulating ice cover in lakes as a function of air temperature: preliminary results from Lake Tovel. *Marco Toffolon* [1] *- Sebastiano Piccolroaz* [1] *- Pietro Todeschi* [2] *- Ulrike Obertegger* [3] *- Giovanna Flaim* [3]

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Ice formation on lake surfaces is a complex process that is attracting increasing interest. Following a recently proposed approach that exploits hybrid models (physically rooted, but with calibrated parameters, see the *air2water* model proposed by Piccolroaz et al., HESS 2013), we developed a simple formulation to predict lake surface temperature (LST) and ice thickness in winter as a function of air temperature alone. Daily averaged LST is simulated by means of an ordinary differential equation where the effect of summer stratification is suitably taken into account. The new element is the sub-model for ice formation, whose thickness is modelled by an additional differential equation solely depending on air temperature. Importantly, no ice thickness measurements are needed for calibration of the model parameters. The model was applied to Lake Tovel (Trentino, Italy), a LTER site (IT09-005-A). The lake (altitude = 1178 m asl; area = 39 ha, volume = 7.4×10^6 m^3, max depth = 39 m) is ice-covered from December to April. Air temperature was measured by a meteorological station located at the lake, while water temperature was provided by a central lake platform equipped with temperature sensors. The dataset covered 6 years (2010-2015), when LST was recorded.
Model outputs satisfactorily agree with the available LST measurements, showing that accounting for ice formation is necessary to correctly predict LST in spring. Moreover, a qualitative comparison of modelled ice thickness with occasional measurements and visual observations suggests that this simple ice model has the potential to be used to reconstruct ice dynamics in other lakes where only air temperature and LST data are known.

27-O   Water temperature in French inland water bodies through models and satellite data.   *Jordi Prats Rodríguez* [1] *- Pierre-Alain Danis* [1] *- Delphine Rebière* [1] *- Natalie Reynaud* [1] *- Thierry Tormos* [2] *- Tiphaine Peroux* [1] *- Juilen Dublon* [1]

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Water temperatures are one of the most important factors of freshwater ecology and lake hydrodynamics. In order to evaluate the effect of water temperatures on fish in inland water bodies at the scale of France we undertook a study linking the advantages of models and satellite data.
We simulated epilimnion and hypolimnion temperature for the period 1999-2013 at 480 French inland waterbodies, both natural and artificial, with a surface of >0.5 km^2. We used three models: (i) the hydrodynamic model FLake, (ii) a modification of the model of Ottosson and Abrahamsson (1998) (OAmod), and (iii) the four-parameter model of Toffolon et al. (2014) (Tea2014, epilimnion temperature only). The Flake model requires no calibration. For the Tea2014 model, the parameter values were estimated using the regressions as a function of depth proposed in the original publication. The OAmod model was derived by the authors and had several calibration parameters.
Water temperature data for calibration and validation came from three sources: 1) temperature profiles measured as part of the European Water Framework Directive monitoring of water quality in lakes; 2) continuous measurements at five water bodies of different characteristics using thermistor chains; 3) surface temperature measurements derived from Landsat 5 and Landsat 7 satellite thermal images processing for all studied lakes in the study period. These data was useful to analyse spatial surface water temperature variability and the characteristics of the annual thermal cycle of French water bodies. Meteorological data were obtained from Météo-France's 8-km-resolution SAFRAN (Système d'Analyse Fournissant des Renseignements À la Neige) reanalysis at the nearest grid point.
Satellite-image processing, which essentially consisted in the correction of atmospheric effects, provided surface temperatures with reasonable accuracy (root mean square error of 1-2 ºC), though they tended to underestimate surface temperatures. Variations in latitude, altitude and continentality explained well the spatial variability in epilimnion temperatures (mean annual temperature, average temperature in Januray-February, average temperature in July-August).
Epilimnion temperature simulation was best for water bodies of between 1 m and 5 m depth. Simulation errors increased for shallower (< 1 m deep) and deeper (> 5 m deep) water bodies. For shallow water bodies (< 5 m), the three models simulated epilimnion temperature comparably well, but for deeper ones OAmod was best.
Two models were used to simulate hypolimnion temperatures: OAmod and FLake. Error levels for the simulation of hypolimnion temperature were higher than for epilimnion temperature. For OAmod, simulation error decreased with water body depth, and it provided better simulations than FLake for water bodies deeper than 2-3 m. FLake gave netter predictions for shallow water bodies of less than 2-3 m, error increased greatly for deeper water bodies.

27-O   Temperature dynamics in very shallow water bodies: the crucial role of heat fluxes at the soil-water interface.   *Mattia Pivato [1] - Luca Carniello [1] - John Gardner [2] - Sonia Silvetri [2] - Marco Marani [3]*

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Water temperature represents one of the crucial factors driving the ecological processes in water bodies. Many contributions are available in the literature that describe temperature dynamics in deep basins as lakes or seas. Those basins are typically stratified which makes important to represent the vertical profile of the water temperature. Dealing with shallow water bodies, such as rivers, shallow lakes and lagoons, simplifies the problem because the water temperature, in many cases, can be assumed uniform in the water column; at the same time, the heat exchange at the soil-water interface assumes an important role in the water temperature dynamics. This process is negligible in deep basins and, to our knowledge, very few studies and data are available in the literature.

In order to provide more insight on this crucial process, we conceived and performed ad hoc field measurements in the Venice lagoon, a worldly famous tidal environment widely studied because of its historical relevance but also because it represents a complex and delicate ecosystem threatened by the effects of climatic change and anthropic pressure. The Lagoon is a shallow tidal basin, about 550 km^2 wide, connected to the sea by three inlets characterized by a tidal excursion of about 1 m, which can suddenly be increased by meteorological forcing.

We selected two locations on a tidal flat in the Venice lagoon close to the Sant'Erasmo island, each location being characterized by a different depth. At each station, we measured the temperature considering 4 points within the water column and 5 points inside the first 1.5 m of the soil. Data were collected in different periods from July 2015 to January 2016 in order to capture the season variations. We used the data to characterize the heat flux at the water-soil interface in different periods of the year and to develop a "point" model for describing the evolution of the temperature in the water column.

Based on the insight on the process provided by the point model, we will develop a module for describing the dynamic of the temperature to be coupled with an already existing 2D model of the Venice lagoon that describes the hydrodynamic, the generation and propagation of wind waves, and the sediment transport in the lagoon. This will permit to describe the spatial and temporal evolution of the water temperature in the lagoon considering the horizontal heat transport that is neglected in the "point" model. The 2D model will be calibrated and tested using both the data collected during the field campaign, integrated with temperature data provided by an existing network of 10 multi-parametric probes, and data retrieved by satellite images.

27-O   Temperature dynamics in a large shallow lake coupling hydrologic - hydrodynamic modelling and remote sensing techniques.   *David da Motta Marques [1] - Maurício Munar [1] - Carlos Ruberto Fragoso Jr. [2] - Juan Martin Bravo [1] - Rafael Cavalcanti [1]*

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Assessment of large-scale effects on the temperature dynamics and processes in shallow lakes requires comprehensive modelling capabilities to simulate water interactions, the processes that occur and its driven forces. In this paper we investigated the spatial and temporal variations in water surface temperature and thermodynamic processes for the period 2000 – 2010, in the Mirim Lake, a large (820km^2) shallow lake between Brazil and Uruguay. The system was examined using in-situ observations, MODIS land surface temperature (M*D11A1 LST) products and a coupled large-scale hydrologic model (MGB-IPH) and three-dimensional hydrodynamic model (IPH-ECO). The simulations results showed that the estimations for water surface temperature were consistent with measured in-situ data and the validated MODIS – derived water surface temperature (WST), from daytime and nighttime time-series. The analysis of the modeling results revealed that the coupled models were able to reproduce temperature dynamics, the spatial and temporal (diurnal, monthly, seasonal and inter-annual) variations and circulations patterns. In addition, model simulations did show an apparent rise in the water surface temperature (WST) in the Lake, along the period 2000 – 2010. Coupled large-scale hydrologic and hydrodynamic models will benefit future modeling efforts by providing an effective tool to study the temperature dynamics, physical and ecological processes in large shallow lakes, and to address the impact of climate change in these ecosystems.

27-O   Comparing simple models to predict river water temperature.   *Sebastiano Piccolroaz [1] - Elisa Calamita [1] - Bruno Majone [1] - Aurélien Gallice [2] - Annunziato Siviglia [3] - Marco Toffolon [1]*

Department of Civil, Environmental and Mechanical Engineering, University of Trento, Trento, Italy [1] - School of Architecture, Civil and Environmental Engineering, École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland [2] - Laboratory of Hydraulics, Hydrology and Glaciology (VAW), Eth-Zürich, Zurich, Switzerland [3]

River water temperature is controlled by the net heat flux that results from multiple processes involving the atmosphere, the hydrologic regime, and the upstream conditions of the catchment. While physically-based models are able to describe the individual processes but require a large amount of data, simpler statistical models are routinely used for long-term predictions, usually considering solely air temperature as predictor variable.
Here we test a suite of hybrid lumped models, belonging to the *air2stream* family (Toffolon and Piccolroaz, Environmental Research Letters 2015), which are derived from physical principles, rely solely on air temperature and streamflow, and are of similar complexity as standard statistical models. We refer to a dataset of 38 Swiss rivers, which includes rivers classified into four different hydrological categories: low-land natural rivers, lake outlets, snow-fed rivers, and regulated rivers. In all cases, *air2stream* models outperform statistical models in the prediction of river water temperature. Moreover, the analysis of the performances of the different versions of *air2stream* contributes to a deeper comprehension of the physical mechanisms controlling river thermal response, to a level that would be inaccessible using simpler regression-based models. An exercise of cross-validation on five windows over a 30-year period further demonstrates that the *air2stream* model is robust and can be suitably adopted for long-term analyses.

27-O   10 years of experimental manipulations to assess the response of flow alteration on river food web.   *Jerome Marty [1] - Jaclyn Brush [2] - Karen Smokorowski [3] - Michael Power [2]*

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10 years of experimental manipulations in a regulated river to evaluate the response of the food web to flow and temperature changes.
Effects of flow alteration on the aquatic biota have predominantly been reported in relation to diversity, and few studies have focused on its effect on food webs. In this study, we applied a Before After Control Impact experimental design (BACI) to determine the response of the food web to fluctuating ramping rates using stable isotopes. Carbon (δ^{13}C) and nitrogen (δ^{15}N) stable isotope values of invertebrates and fish were compared under restricted (2002/2004) and unrestricted (2005/2012) ramping rate flow regimes. Study control sites consisted of 3 sites on the unregulated Batchawana River and one upstream site on the Magpie River. Two sites situated below the Steephill dam on the Magpie River were considered as impacted sites, subject to ramping rate variations. The unrestricted ramping rate flow regime had little impact on the transfer of carbon through the food web as no significant differences in δ^{13}C values were found when applying BACI analysis to each trophic level of the food web. However, macroinvertebrate and fish δ^{15}N values were significantly higher in the impacted sites compared to the control sites, with the trend toward differences being greatest under unrestricted ramping rate for macroinvertebrates. The changes may result from the physiological response of organisms to water temperature changes. Food web length, calculated based on the difference between macroinvertebrate and fish δ^{15}N values, was also affected by the flow regime and was significantly shorter under the unrestricted ramping flow regime, implying a shift in the diet of fish toward lower trophic level invertebrates. Results from this study highlight the influence of ramping rates on the functioning of the lotic food web, suggesting the need for information on flow alterations to be considered in river management decisions.

27-O   Assessing the impacts of pumped-storage operations.   *Ulrike Gabriele Kobler [1] - Martin Schmid [1] - Alfred Wüest [2]*

Surface Waters - Research And Management, EAWAG, Kastanienbaum, Switzerland [1] - Aphys, Epfl, Lausanne, Switzerland [2]

Pumped-storage hydropower plants are considered to be an important component of the future energy system in Europe for storing intermittent renewable electricity. If they involve natural lakes as storage reservoirs, the effects of pumped-storage operations on the physical properties of these lakes, such as temperature, stratification and ice cover, as well as water quality, need to be limited to an extent that lake ecology is not seriously affected.

Previous modelling studies on the impact assessment of pumped-storage operations used either a two-dimensional or a three-dimensional modelling approach. Furthermore, those studies focused on the determination of hydrodynamic impacts.

Hence, this study quantifies the impacts on hydrodynamics and water quality at the example of a pumped-storage hydropower plant between Sihlsee (upper reservoir) and Upper Lake Zurich (lower lake) in Switzerland. Therefore, the modelling results of a two-dimensional model (CE-QUAL-W2) as well as a three-dimensional (Delft3D) model are compared. The discussion of these results allows, moreover, to determine the required model complexity to achieve reliable projections.

27-O   The mechanism of hypolimnion warming induced by internal waves.   *Alon Rimmer, Aminadav Nishri, Yury Lechinsky*

Israel Oceanographic & Limnological Research, The Kinneret Limnological Laboratory, Israel

The measured temperature of the hypolimnion of Lake Kinneret, Israel, reveals an average rise of ~0.6±0.3 °C between April and December. Three mechanisms are suggested as the cause of this rise: (i) direct radiation; (ii) an entire-lake vertical diffused heat transfer, and; (iii) a mechanism of "indirect warming", which is investigated here for the first time. The indirect warming mechanism prevails in the sub-littoral zones, which are affected by internal seiche activity, including Poincare and Kelvin waves with cycle periods of ~12 and ~24 hours, respectively. During part of the seiche's time span, the warm epilimnetic water comes into contact with the underlying bottom sediments and heats them. During the rest of the seich's cycle, part of the sub-littoral bed sediments which become overlain by cold hypolimnetic water, emit their heat, which slightly warm the hypolimnion. The daily cycle of this indirect warming mechanism is superimposed on the seasonal temperature cycle of the sub-littoral bed sediments, in accordance with the epilimnion's temperature. Empirical evidence suggests that indirect warming actually takes place in response to well-documented seiche water motions. According to the proposed analysis of sediment temperature changes, in the month of June a daily heat flux of 7.88 W m^{-2} (0.68 MJ m^{-2} d^{-1}) was estimated. It was found that during the first five months of stratification this mechanism contributes ~41% of the thermal energy needed for the 0.6^{0}C temperature increase. This mechanism is expected to occur at thermally stratified lake that is significantly affected by internal seiche activity.

27-O   Hydrodynamics of Lake Erie in winter.   *Dmitry Beletsky [1] - Raisa Beletsky [1] - Jia Wang [2] - Nathan Hawley [2]*

Ciler, School of Natural Resources And Environment, University of Michigan, Ann Arbor, United States [1] - Great Lakes Environmental Research Laboratory, Noaa, Ann Arbor, United States [2]

Winter circulation in the Laurentian Great Lakes is insufficiently studied and impacts of ice on lake circulation and ecology are poorly understood. Lake Erie, the shallowest of all Great Lakes, is at least partially covered with ice from December until April and its normal peak ice cover is about 90%, the highest of all Great Lakes. Here, we analyze and compare Lake Erie circulation patterns using data from two major observational campaigns conducted during icy winters of 1979-1980 and 2010-2011. Observed circulation patterns are supplemented with results of a three-dimensional coupled Great Lakes Ice-circulation Model (GLIM) that has 20 vertical levels and a uniform horizontal grid size of 2 km. The model is validated with ice concentration data and temperature and current measurements at multiple moorings deployed in the lake's central basin.

27-O   Energy fluctuations in a large enclosed basin influenced by geostrophic flow.   *Michio Kumagai [1] - Yasuaki Aota [2] - Guillaume Auger [2] - Richard D Robarts [3]*

Lake Biwa Sigma Research Center, Ritsumeikan University, Kusatsu, Japan [1] - R-giro, Ristumeikan University, Kusatsu, Japan [2] - Director Board, World Water And Climate Foundation, Saskatoon, Canada [3]

In large-scale enclosed basins located in the middle latitudes, such as Lake Biwa the largest lake in Japan, water movements are affected by Earth's rotation. Such water movements are known as geostrophic flows. In order to estimate the energy level of water fluctuations in Lake Biwa, especially in the epilimnion, we deployed an ADCP (Acoustic Doppler Current Profiler) 2 km off the east shore and measured water currents from 2010 to 2012. The measurements covered both the stratified (April to October) and non-stratified (November to March) seasons. The ADCP operated with bursts of 1 hour. Two hundred data points per burst with one second intervals and per depth interval of 1 m were collected. The ADCP was dormant during the intervals. The dominant period of hourly fluctuations was 3 to 5 sec. Energy level fluctuations were almost constant in the water column from 6 m to 25 m depth. We found that the magnitude of fluctuations was the same order as mean horizontal flow during the non-stratified season and was nearly 30% of mean flow during the stratified season. This was due to the geostrophic gyre becoming dominant during the stratification period so that mean horizontal flow in the epilimnion obtained more energy than the mean flow in the non-stratified period. The energy level fluctuations were close to constant year round and were maintained at a higher level than we expected. The major reason for this occurring in an enclosed basin was the excitation and reflection of different types of waves. When we examined geostrophic flow in Lake Biwa using seven floats with GPS trackers, we noticed that each rotated counter-clockwise in summer and each had individual fluctuations. Therefore, neighbouring buoys did not behave exactly the same way and sometimes moved in an oscillating pattern. A geostrophic gyre in a large-scale enclosed basin can be considered as an energy accumulated system within a basic geostrophic flow and fluctuations.

27-P   Unexpected vertical shear in very shallow bay of Lake Champlain, Vermont: implications for management & modeling.   *Thomas Manley [1] - Zachary Perzan [1] - Patricia Manley [2] - Emily Wei [3]*

Middlebury College, Department of Geology, Middlebury, United States [1] - Middlebury College, Department of Geology, Middlebury, Venezuela [2] - Scripps Institute of Oceanography, Scripps Institute of Oceanography, La Jolla, United States [3]

Missisquoi Bay, which is located in both Canadian and US waters in the northeast portion of Lake Champlain (NY-Vermont), is a uniformly shallow bay with a mean depth of slightly less than 3 m. During a six-month monitoring program in 2013, an array of ADCPs, water level gauges, vertical temperature strings and meteorological sensors were used to monitor the bay's hydrodynamics. Water level data showed that the bay rapidly responded to changes in wind forcing within 40 minutes. Surprisingly, the initial assumptions that circulation within the bay would be primarily barotropic in nature (i.e., well-mixed from wind forcing) and that a simple, but modified, dipole circulation pattern would be the typical resultant flow field were proven to be incorrect over 50% of the time from late-June to late-September. This anomalous departure was directly related to the development of a weak thermal stratification that was surprisingly maintained over long periods of time. As a consequence of this very shallow thermal stratification, nearly-opposed 2-layer flow forced by downwelling / upwelling dynamics was found to be prevalent over the entire Bay. Richardson numbers showed that these vertical-shear events to be non-turbulent due to the presence of the weak, but nevertheless stabilizing, thermal stratification. With respect to wind forcing and its effect on thermal stratification, three separate wind regimes were identified: 1) winds < 6 m/s allowed thermal stratification to remain intact, 2) winds 6-8 m/s commenced stratification break down and 3) winds > 8 m/s caused the water column to be rapidly and uniformly mixed. Circulation patterns within the upper and lower layers of the water column were found to be significantly different than that of a resulting vertically-averaged flow field. It is also well-known that circulation dynamics represents an integral component in the understanding of chemical, biological and sedimentological movement yet, in many cases, management decisions affecting these shallow bodies of water were (and most likely still are) based on a vertically-integrated water column. ADCP and thermal data collected within Missisquoi Bay over several years indicate that the opposite is true and that management decisions for shallow water bodies having a depth of 2-3 m would significantly benefit from the use of multi-layer numerical models.

27-P   Four-modes of circulation dynamics found within a shallow bay (Missisquoi Bay) of Lake Champlain, Vermont and Canada.   *Patricia Manley, Thomas Manley, Zachary Perzan*

Middlebury College, Department of Geology, Middlebury, United States

Missisquoi Bay, which is located in both Canadian and US waters in the northeast portion of Lake Champlain, is a uniformly shallow bay with a mean depth of slightly less than 3 m. With a surface area of 78 km², it is the 3rd-largest physical feature of the lake with the Main Lake (683 km²) and Northeast Arm (269 km²) being the first two major sectors. Three rivers that discharge into Missisquoi Bay (the Missisquoi, Pike and Rock) have drainage areas totaling 2900 km² that are primarily located in agricultural settings. In the mid-1800s, a large rock-filled causeway was built across 1200 m wide southwest channel which provided the only access to Lake Champlain. Only ~200 m of the original channel was left open for water movement. As farming practices continue to develop within the drainage basins, so did the amount of phosphorus accumulation and unsightly/unhealthy algal blooms of blue-green algae. Even though numerical modeling of the bay showed that there would be no significant improvement in water quality even if the entire causeway was removed, the narrow channel was opened up by an additional 100 m by the state of Vermont in an effort to balance the public outcries of highly eutrophic conditions as well as the rock-filled causeway becoming a breeding site for an endangered species. Unfortunately, this management model was only verified against a single ADCP record of ~6 weeks and a few surface drifter tracks during that time period. During a 3-year monitoring program, arrays of ADCPs, water level gauges, vertical temperature strings and meteorological sensors were used to monitor the bay's hydrodynamics. From this program, four basic modes of circulation were found to exist. The first is defined as "wintertime sluggish" wherein water velocities are vertically uniform and on the margin of detectability by the ADCP. The second mode is "spring melt" where all three river inputs were maximized with high-volume flows. The third and fourth modes were confined when stratified conditions could exist (May-November) but were divided up into those times when the water column was well mixed (mode 3 - "well-mixed summer") and when stratified conditions led to highly dynamic 2-layer flow (mode 4 - "two-layer summer"). All of the four modes exhibited unique circulation dynamics that if modeled correctly, would provide greater insight to the chemical, biological and sedimentological transports within the bay as well as creating a more informed public and management with regards to phosphorus dynamics related to the causeway.

27-P   Comparing the truthfulness and accuracy of different interpolation methods in modelling heliothermal phenomena in several Romanian salt lakes, using GIS techniques.   *Bretcan Elena Simona [1] - Serban Gheorghe [2] - Zaharia Liliana [3] - Alexe Mircea [2]*

University of Bucharest, Faculty of Geography, Doctoral School Simion Mehedinti, Bucharest, Romania [1] - Babes-bolyai University, Faculty of Geography, Cluj-Napoca, Romania [2] - University of Bucharest, Faculty of Geography, Bucharest, Romania [3]

Water temperature is a key element in the development and functioning of lacustrine ecosystems. In the case of salty lakes, the variation and distribution of the water temperature is conditioned by the type of thermal stratification, the solubility of the oxygen dissolved in the epilimnion, salinity, conductivity, pH, development and density of the halophile organisms. The heliothermia phenomenon (positive thermal anomaly) is met in natural salty lakes or anthropic-saline lakes, in which a mesothermal layer emerges, usually within the depth limits 1.5-4 meters, in between two horizons whose temperatures are lower. The phenomenon occurs due to solar radiation, but is strictly conditioned by the salinity distribution vertically (the presence of the halocline) and closely depends on the precipitations regime, input sources and anthropic influence.

In the present work are analyzed lakes, both karst-saline lakes (Ursu from Sovata), and formed in former salt mines (Bătrân of Ocna Sugatag, Doftana and Dulce of Telega, Ocnita of Dambovita) whose depths range between 10 and 20 m, and are used, in general, in spa treatment. To analyze the spatial distribution of the water temperatures, both horizontally and vertically, we have used the spatial interpollation teachniques offered by the Geographic Informatic Systems (GIS) and those included in the ArcMap 10.3.2 programme, realizing both a 2D and a 3D modelling of the phenomenon.

To analyze these data statistically, we have used the programmes Microsoft Excel and SPSS. The correlation coefficient between the values measured and those estimated presents different values (0.6-0.9) both from one lake to the next and depending on the interpollation method used: Inverse Distance Weighted (IDW) versus Kriging (circular, Gaussian, spherical, exponential). Since our database also contains other parameters that have been measured (salinity, conductivity, pH, dissolved oxygen), we have been able to use the cokriging interpollation function (Kriging with secondary variables), which has improved the accuracy of the estimated values. The spatial analysis of the temperatures, vertically, in the lakes evaluated, was not efficient using lineary estimation methods (Ordinary Kriging, Simple Kriging); much more efficient appeared to be the summative local estimation methods using parametric methods (Disjunctive Kriging) or non-parametric methods (Kriging Indicator). The comparative analysis of the values obtained for the 5 lakes

(carried out in over 1200 points) reflects the particularities of the spatial variation of the water temperature, the accuracy of the values estimated being directly dependent on the interpollation method used, on the density of the points used for interpollation, their distribution and the spatial variability of the secondary predictors (salinity, conductivity). Using Fisher`s z transformation, we have compared the correlation coefficients obtained for the values estimated, to determine the significance of these differences.

27-P   Changes in carbon and ionic species in a tropical monomitic reservoir from stratification to mixing.   *Maria Isabel Rocha, Samira da G. Portugal, Christina Castelo Branco*

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The Ribeirão das Lajes reservoir (RLA) was built in 1905 for power generation, and domestic water supply. The RLA presents oligotrophic condition, low human activities and the surrounding area covered by the Atlantic rain forest. The retention time of the water (300 days) and fish-farming activities in one of its arms might cause a decrease in the quality of its waters in the next years. RLA is warm monomitic, exhibiting water column mixing in the winter. We investigated vertical and seasonal fluctuations of physical and chemical properties, carbon and ions species in water column of RLA. Since wetter climate results in more export of dissolved organic carbon (DOC) to lakes we expected a dominance of DOC in the water column in mixing and in the epilimnion during stratification. We also expected a decrease in DOC after a long time (8 months) since the onset of stratification. Samplings were performed in mixing of 2014 (August) and at the end of the stratification in 2015 (April) at multiple depths over the deepest point (40m). Multi-parameter probes, radiometer, total carbon analyzer and ion chromatograph were used. Dissolved oxygen (DO) concentration (mg.L^{-1}) in mixing ranged from 8.0 at the surface to 4.83 in the bottom and in stratification was 8.15 at the surface and dropped to 0.59 at 10m. Water electrical conductivity (EC), total suspended solids (TDS), pH, chlorophyll-*a*, NO_3, DOC, total organic carbon (TOC) and total carbon (TC) showed significant differences in values between mixing and stratification (Mann-Whitney test, $p<0.05$). While in mixing there were no differences in all variables along the profile, in the stratified condition vertical changes of water temperature (WT), DO, EC, TDS, ORP, NH_4, and IC were statistically significant using Kruskal-Wallis test. In mixing IC>DOC. In stratification DOC>IC in epilimnion, but DOC=IC in metalimnion and IC>DOC in the hypolimnion. Besides anoxia, the stratified conditions for months created a hypolimnion with negative values of ORP, increased content of NH_4 and IC towards a decrease of DOC, attesting the degradation of organic matter. IC was positively correlated (Spearman correlation, $p<0.05$) with NH_4 and negatively with ORP, showing results from microbial respiration of organic matter, consuming electron acceptors (NO_3) and producing NH_4. DOC was positively correlated with chlorophyll-*a* and DO suggesting autochthonous source for carbon. The prevalence of hypolimnetic anoxia suggested that in the RLA oligotrophic condition primary production is unlikely to provide sufficient carbon (C) to account for the observed decrease in DO. DOC increased slightly in the stratified profile in both metalimnion and hypolimnion what could suggest that other sources of organic C than phytoplankton are also important for hypolimnetic metabolism. As in other tropical lakes, allochthonous DOC from surroundings forested soils and autochthonous C from sediments may have been those sources.

27-P   Effects of the ongoing changes of the diurnal temperature range on the stratification of lakes.   *Elena Roget*

Universitat de Girona, Girona- Catalonia, Spain

Air temperature is one of the leading variables of the heat surface fluxes which directly influence the sensible heat and long wave radiation components of the total flux and why it is assumed that significant diurnal fluctuations in air temperatures can also lead to diurnal variations of stratification in the surface waters and even influence the water stratification itself.
Changes in the diurnal temperature range (DTR) have been linked not only to global warming, but also to a variety of local effects. Several authors pose that the increase in the DTR around the Aral Seas is because of its desiccation process. The Aral Sea is a paradigmatic example of the ongoing drawdown of lakes and large reservoirs around the world resulting from massive irrigation policies and/or persistent droughts caused by climate change (E.g. Lake Poopó in Bolivia, Lake Urmia, in Iran, Lake Chad in Africa, Lake Mead in the USA, etc.). The Aral Sea is located in Central Asia where a global positive trend of the DTR has been identified in the entire region. In this present study, temperature data from 1990 to 2010 from 32 stations located around the lake have been analyzed in detail to distinguish the background DTR changes from local effects and quantify them.

The analysis of the variation of the DTR during these two decades clearly corroborates the influence the shrinking eastern lobe of the Aral Sea during this period has had on the increase of the DTR in the region. At the stations closest to the sea, and where the shoreline has greatly retreated, there was an increase in the DTR of up to as much as one degree in a ten year period. In general, however, the DTR positive trend decreases with distance. The lower DTR trends are observed at the stations along the Amu Darya river basin and at the station closest to the Caspian Sea.

A detailed analysis of the evolution of the DTR in the region is presented. Further, the impact of the observed DTR trends on the water column is discussed based on numerical results from a simple one dimensional model and considering different background stratifications and meteorological forcings.

27-P Are deep tropical lakes regular in the timing of the seasonal mixing? A 16-year temperature data set from Lake Alchichica, Mexico.   *Benjamín Quiroz-Martínez[1], Javier Alcocer[2], Elva Escobar-Briones[3]*

Instituto de Biologia - Universidad Nacional Autónoma de México [1], Facultad de Estudios Superiores Iztacala.-Universidad Nacional Autónoma de México [2], Instituto de Ciencias del Mar y Limnología - Universidad Nacional Autónoma de México, Ciudad de Mexico, Mexico [3]

Talling (1969) as well as Lewis (1987) reveal tropical lakes that are sufficiently deep to stratify tend to mix predictably at a particular time of year and to remain stratified for the remainder of the year. The mixing season coincides with the hemispheric winter. This conclusion came mostly from studies on African lakes and further from other examples in Asian and South American. However, the long-term databases from tropical lakes to confirm this are seldom. In general, tropical lakes both stratify and mix more easily than temperate lakes in response to changes in wind strength and to reversals in the heat flux. This is expressed through a highly variable mixed layer thickness in tropical lakes, compared with the quite regular mixed layer thickness in temperate lakes. Alchichica is a tropical (19º24' N), small (surface = 2.3 km^2), almost circular, and deep (maximum depth = 62 m, mean depth = 40.9 m) lake. It is fed by saline and alkaline groundwater

27-O   Stratification and mixing of two tropical reservoirs of the Caribbean.   *David Sotomayor-Ramírez[1], Gustavo Martinez-Rodriguez[2]*

Department oof Agro-environmental Sciences, College Of Agricultural Sciences, University of Puerto Rico, Mayagüez, Puerto Rico [1] - Agricultural Experiment Station; Department Of Agro-environmental Sciences; College of Agricultural Sciences, University of Puerto Rico, Mayagüez, Puerto Rico [2]

Lake circulation in the tropics is influenced by incident solar radiation, storms, wind, and hydrologic inflow. The extent of stratification will influence hypolimnetic dissolved oxygen (DO) consumption that will affect primary and secondary productivity and trophic status. Within similar solar energy inputs, primary productivity may cause reduced light penetration, increasing the duration and the depth to hypolimnion and enhancing the extent of stratification. The seasonal pattern of stratification and mixing was examined for two reservoirs of contrasting geographic location and trophic status within dry (Patillas) and humid (La Plata) tropics in Puerto Rico, Caribbean basin (near 18.45oN, 66.1oW). The annual renewal frequency of Patillas is 4.5 and La Plata is 8.2. The reservoirs were monitored during an 18 month period from Spring 2012 to Summer 2014 and 24 sampling incursions at each reservoir were completed. Vertical depth (z) profiles of temperature, specific conductance, dissolved oxygen, turbidity, sechi-disk, were recorded and total nitrogen (N), total phosphorus (P), and chlorophyll a (chl a), were measured at discrete depths. Patillas is oligotrophic with epilimnetic median total N, total P and Chl a concentrations of 0.19 mg/L, 7 µg/L and 4.56 µg/L, respectively. La Plata is eutrophic with epilimnetic median total N, total P and Chl a concentrations of 0.55 mg/L, 45 µg/L and 21.83 µg/L, respectively. La Plata had greater instances of stratification (delta T/delta z > 0.25) which occurred at shallower depths than Patillas. Seasonal patterns of water column stability (J/m2) were similar. Physico-chemical data and bathymetry was used to calculate water column stability (J/m2). Seasonal patterns of water column stability were similar. There was lower water column stability (< 50 J/m2) during the hemispheric winter (December to March) and increased as air temperatures increased in the spring reaching a maximum (250 J/m2) near summer (July to September). Stability decreased during the fall to winter transition. During the fall to winter transition there is increased incidence and intensity of storm events which may contribute to transient periods of mixis and hence oxygenation of deeper parts of the water column. While La Plata was anoxic at depths > 4m, Patillas had deeper depths to anoxia and transient periods of oxygenation primarily associated with seasonal winter and to a lesser extent precipitation and hydrologic inputs. The level of stability was higher during the winter of 2014 than winter 2012 and winter 2013, possibly associated with lower antecedent precipitation in 2014. Our observations are being used to evaluate the extent of hypolimnetic oxygen consumption, identify the factors that promote hypolimnetic oxygenation, and nutrient-primary productivity relationships.

28. THE ADAPTIVE ROLE OF PHYTOPLANKTON PHENOTYPICAL VARIABILITY UNDER DIFFERENT ENVIRONMENTAL CONSTRAINTS

28-O   Morphological variability of phytoplankton in lakes and reservoirs of Sicily (Italy).   *Luigi Naselli-Flores*

Dept STEBICEF, University of Palermo, Palermo, Italy

There is a growing interest in understanding how phytoplankton morphological features can be related to environmental variability. The need to optimize resource exploitation and, at the same time, to deal with water movements strongly influences phytoplankton morphology and species-specific size variation has an adaptive value. The analysis of the morphological size variation of the whole assemblage has therefore implications in the biomonitoring of aquatic ecosystems. We need to understand how the complex of environmental constraints synergistically act on the morphology of phytoplankton species. This kind of analyses may represent a powerful tool to clarify aquatic ecosystem functioning, assess impacts exerted by climate change, and improve water resource management plans. This presentation, through the analysis of data collected in several natural and artificial lakes in Sicily, attempts to show how morphological variability of phytoplankton may reflect the physical (hydrodynamical) context in which these organisms grow, and highlight the role of their size in nutrient uptake, and that of their shape in light harvesting.

28-O   Seasonality of intra-specific cell size in the phytoplankton of Lake Kinneret.   *Tamar Zohary* [1] - *Miki Shlichter* [1] - *Luigi Naselli-Flores* [2]

Kinneret Limnological Laboratory, Israel Oceanographic & Limnological Research, Migdal, Israel [1] - *Dept STEBICEF, University of Palermo, Palermo, Italy* [2]

A distinct pattern of seasonal fluctuations in intra-specific cell size and/or colony size was observed in a large number of phytoplankton species from Lake Kinneret, Israel. The same species showed larger cell size or colony size in winter and smaller size in summer, with intermediate sizes in the interim periods. This phenomenon was exhibited by species of chlorophytes, dinoflagellates and cyanobacteria that were abundant enough to be sampled (fortnightly) and measured throughout the year. The annual pattern of fluctuations in size repeated itself over 8 consecutive years (2004-2012). The size fluctuations were independent of the temporal changes observed in cell abundance of each species. Rather, peak sizes coincided with lowest water temperature and highest nutrient availability, minimum sizes with highest water temperature and lowest nutrient availability. These observations fit well with current ecological theory on organism size, where larger organisms occur in colder climates and the reverse in warmer climates.

28-O   Self shading effects on growth vary with cyanobacterial species, strains and morphologies.
Man Xiao [1] - *Anusuya Willis* [1] - *Kate O'Brien* [2] - *Michele Burford* [1]

Australian Rivers Institute, Griffith University, Brisbane, Australia [1] - *School of Chemical Engineering, University of Queensland, Brisbane, Australia* [2]

Harmful cyanobacterial blooms pose severe water quality problems in freshwater ecosystems and drinking water supplies. High nutrient loads are a key driver of cyanobacterial blooms, but the contribution of physical factors in controlling growth, as well as species and strain dominance is less well understood. This includes the effect of self-shading by algal blooms reducing light availability through the water column. Therefore, we examined the effect of self-shading on growth of multiple strains of two cyanobacterial species, and how this response interacts with temperature. The two species had very different light requirements, *Cylindrospermopsis raciborskii* (9 strains) preferred lower light conditions, compared with *Microcystis aeruginosa* (4 strains). As a result, self-shading appears to have a greater effect on *M. aeruginosa* than *C. raciborskii.* In addition, we found variability in strain responses to self-shading which appeared to be related to differences in the morphology and the cell size of strains. There was a larger variation in the growth responses to light between the *C. raciborskii* strains with straight morphology compared with among the coiled

morphology. This study showed that morphology, cell size and temperature can all affect the response of strains and species to light. It highlights the need to understand strain variation and how this affects their response to environmental constraints in order to improve prediction of cyanobacterial bloom formation and community structure.

28-O   Functional traits of lake phytoplankton across europe and their response to environmental gradients.   *Giuseppe Morabito* [1] - *Gabor Borics* [2] - *Jordi Catalan* [3] - *Ute Mischke* [4] - *Agnieszka Pasztaleniec* [5] - *Birger Skjelbred* [6]

Institute For Ecosystem Study, ISE CNR, Verbania, Italy [1] *- Hungarian Academy of Sciences, Danube Research Institute, Debrecen, Hungary* [2] *- Spanish National Research Council, Centre for Advanced Studies of Blanes, Blanes, Spain* [3] *- Leibniz-institute of Freshwater Ecology and Inland Fisheries, Department I - Ecohydrology, Berlin, Germany* [4] *- Institute of Environmental Protection, NRI, Department of Freshwater Assessment Methods and Monitoring, Warsaw, Poland* [5] *- Norwegian Institute for Water Research - NIVA, Center For Freshwater Research, Oslo, Norway* [6]

We analyzed the distribution of nine phytoplankton functional traits (unicellular shape, non-filamentous colonial shape, filamentous colonial shape, presence of flagella, potential heterotrophy, size larger than 40 µm, nitrogen fixation, presence of silicified structures, presence of gas vacuoles) and their dominance along environmental gradients in lakes across Europe. The analysis is based on phytoplankton composition and water chemistry data extracted from pan-European databases compiled for the WFD intercalibration process and the EU Rebecca and WISER projects. The working database includes 831 lakes for phytoplankton data and 408 lakes for abiotic variables, mainly from Northern and Central Europe. Spatial and environmental relationships among samples were explored using several and complementary statistical techniques. Most of the phytoplankton traits are present across a wide spectrum of environmental conditions and their trait distribution was not independent of the geographic position. A key driver appears to be a combined effect of trophic status and lake morphology (high depth-low chlorophyll, vs high chlorophyll-low depth), particularly for traits such as the presence of gas vacuoles and nitrogen fixation capacity.

28-O   Phenotypic plasticity in *Chlamydomonas reinhardtii*: an adaptive response to copper stress.
Giulia Cheloni, Vera I Slaveykova

Institute F. A. Forel, University of Geneva, Geneva, Switzerland[)]

Microorganisms have developed multiple strategies to face adverse environmental conditions and maintain cellular homeostasis. Phytoplankton are characterized by a great phenotypic plasticity and amazing morphological variability, both playing a primary role in the acclimation to changing environments. Besides dealing with changes in environmental parameters, phytoplankton might have to face the presence of micropollutants. If only few data are available about morphological variability as a function of environmental conditions, even less is known about changes in phenotypic plasticity as adaptive responses to micropollutant stress. We thus had a retrospective look at our phytoplankton environmental toxicology data under a "morphological" perspective. The results that we present here highlight the change in cell size of the green alga *Chlamydomonas reinhardtii* in presence of sub-toxic concentrations of copper. Changes in *C. reinhardtii* traits upon exposure to increasing copper concentrations were monitored via flow cytometry and microscopy. Flow cytometry revealed a shift in the size of the *C. reinhardtii* population exposed to copper concentrations higher that 5 µM. The shift in size was observed starting from 48 hours incubation and reached a maximum after 96 hours. Parallel microscopic inspection revealed larger cells after 48 hours and colony formation starting from 72 hours incubation. Colonies attained a size of more than 40 µm, containing 16 or more cells after 96 hours incubation. The primary cell size of this strain ranges between 4 and 6 µm. When colonies were harvested, rinsed and inoculated in fresh medium without copper *C. reinhardtii* cells reverted to their unicellular lifestyle. *Chlamydomonas* palmelloid (colony) formation is a poorly understood phenomenon that was previously reported under adverse environmental conditions and predator pressure. More work is currently performed to investigate whether palmelloid formation is associated to lower cellular stress and/or to lower intracellular copper content. In fact, if the high surface-to-volume ratio of small cells confer and advantage for nutrients uptake, the low surface-to-volume ratio of big cells or colonies might represent an advantage in presence of harmful chemicals. From an ecotoxicological perspective, the observed phenotypic plasticity of *C. reinhardtii* in presence of copper might have important outcomes on the current knowledge of metals effects on the food chain.

28-O The effect of *Daphnia* infochemicals on the filament morphology and cell wall thickness of filamentous cyanobacteria. *Lukasz Wejnerowski* [1] *- Slawek Cerbin* [1] *- Katarzyna Maria Wojciechowicz* [2] *- Tomasz Jurczak* [3] *- Malgorzata Glama* [4] *- Dziuba Marcin* [1]

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Recent work has shown that the filamentous cyanobacterium *Aphanizomenon gracile* strain SAG 31.79 increases in thickness and decreases in length in the presence of *Daphnia* infochemicals. The aim of this study was to test whether the observed changes in filament morphology of SAG 31.79 are widespread response in filamentous cyanobacteria to the presence of *Daphnia* infochemicals and whether the increase in filament thickness is the result of thicker cell walls in cyanobacterial cells.

Morphological and ultrastructural responses of filaments to *Daphnia* infochemicals were tested experimentally on eleven cyanobacterial strains (non-toxic and toxic strains) from different genera such as *Aphanizomenon*, *Cylindrospermopsis*, *Geitlerinema*, and *Planktothrix*. All strains were cultivated under standardized laboratory conditions in flasks filled with WC medium. Examined strains were cultivated using semi-continuous culture technique. Experimental cultures were grown for ten days in continuously mixed flasks. The following treatments were distinguished for each of the eleven strains: 1 a control with filtered WC medium, 2 filtered WC medium after previous incubation with *Daphnia* in it, and 3 filtered WC medium with octyl sulphate, which is a commercially available *Daphnia* kairomone. Freshly prepared culture medium filtrates were added every second day to all cultures. After the experiment, samples were taken for analyses of filament morphology (thickness and length), heterocyte frequency (for some Nostocalean cyanobacteria), and ultrastructural analyses of the cell wall thickness using transmission electron microscopy (TEM).

The results of the experiment showed that most of cyanobacterial strains from the order Nostocales increased in thickness in the presence of *Daphnia* exudates and octyl sulphate, some nostocalean strains grew thicker only in the presence of either *Daphnia* exudates or octyl sulphate. In contrast, Oscilatorialean strains did not react to *Daphnia* infochemicals except one strain of *Planktothrix* and one strain of *Geitlerinema* that reacted only to the presence of octyl sulphate but the direction of the reaction was opposite; reduction of filament thickness. The effects of *Daphnia* infochemicals on filament length were negligible in most examined strains except one strain of *Cylindrospermopsis*, which possessed longer filaments when the octyl sulphate was present in the medium. Our results indicate that filament thickening in the presence of *Daphnia* infochemicals is widespread response only in Nostocalean cyanobacteria.

28-O The influence of info-chemically induced morphological changes in *Aphanizomenon gracile* on *Daphnia* life-history. *Slawek Cerbin*, *Lukasz Wejnerowski, Anna Kozlowska, Marcin K. Dziuba*

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Recently it was found that freshwater cyanobacterium *Aphanizomenon gracile* becomes thicker in the presence of zooplankters or their cues. It seems that the *Aphanizomenon*'s filaments in the presence of *Daphnia* switch their growing mode and invest more heavily in width. One of the explanations of morphological changes points at a defense strategy that allows *Aphanizomenon* to reduce grazer's pressure. If this hypothesis is true, *Aphanizomenon* with induced thick filaments should be more harmful to *Daphnia* than thinner, not induced filaments. Freshwater filamentous cyanobacteria are known to negatively affect the life history of *Daphnia* and we expected that thicker filaments would prolong their time to maturation, reduce the size at first reproduction and number of newborns in higher extend than 'normal', not induced filaments.

We used a non-toxic strain of *A. gracile* (SAG 31.79). Cyanobacteria used in life-history experiments were grown in six chemostats. Half of the cultures received pure WC media in order to grow not induced filaments, and half received WC media with daphnid's cues. Chemical cues were released by daphnids immersed in WC media, placed in cages made of plankton net. Then the media were pumped via filter (0.2µm pores) into the chemostats with cyanobacteria. The morphology of filaments was monitored every second day, and when the differences in filament thickness between two types of algal cultures became significant, the life-history experiment was started with clones of *D. pulicaria* and *D. longispina* complex. Animals were placed individually in tubes divided into 3 food types (treatments): i) *Acutodesmus*

obliquus only (good quality food), ii) *A. gracile* not-induced (thin filaments) + *A. obliquus* and iii) *A. gracile* induced (thick filaments) + *A. obliquus*. In order to exclude the potential supplementation with nutrients released by daphnids, that can support cyanobacteria growth, we repeated the experiment and used commercially available *Daphnia* kairomone (sodium octyl sulphate). Using the kairomone allowed us to exclude the impact of nutrient supplementation.
We will present results showing that the response of daphnids was clone dependent, but generally in agreement with previous studies showing that larger species are more prone to filaments regardless the width. However, some of the smaller clones exhibited enhanced growth and reproduction in the presence of filaments grown with daphnids' cues. We will also present results for daphnids that were fed filaments grown with pure *Daphnia* kairomone.
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28-O   Phytobioimaging a virtual research environment (Phyto-VRE) on phytoplankton for morphological and demographic traits computation.   *Elena Stanca, Leonilde Roselli, Nicola Fiore, Annita Fiocca, Alberto Basset*

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Phytoplankton contribute to about 95% of productivity in aquatic ecosystems and affect key biogeochemical processes, dynamics and structure of higher trophic levels. In the context of conservation, protection and management of the aquatic resources, phytoplankton is one of the most important biological quality element in biomonitoring programs. Classical taxonomic and most recently non taxonomic approaches provide a more comprehensive understanding of the ecosystem functioning, which is one of the pillar for the marine strategy directive (MSFD, 2008/56/CE).Demographic and morpho-functional traits of phytoplankton are the most commonly used for these purposes. Therefore, the right assessment of these traits becomes fundamental. Here, we present *Phytobioimaging*, a research infrastructure capable of managing and processing knowledge on phytoplankton data by a set of computational services. *Phytobioimaging* Virtual Research Environment (Phyto-VRE) is a first attempt of web-based working environment, in which researchers and analysts use several tools for demographic and morphological traits calculation. Particularly, Phyto-VRE consists of i) an Atlas of shapes characterized by a set of 51 geometric models, including cell linear dimensions to measure and biovolume and area equations; ii) a data template to harmonize raw data compilation and iii) a set of computational tools to calculate demographic and morphological traits and some multimetric indicators to assess the ecological status of transitional and marine ecosystems. In addition, Phyto-VRE becomes a data repository where researchers can share their own data, thus strongly increases the value of the precious information they provide. Therefore, in Phyto-VRE, groups of scientists and analysts find a user friendly and transparent access to both a set of computational tools and sharing data facility. Based on ecological informatics technology, Phyto-VRE plays a significant role supporting data computing and interoperable exchange of information and knowledge on phytoplankton.

28-O   Responses of the phytoplankton diversity (taxonomic and functional) to environmental gradients in tropical reservoirs.   *Juliana Santos, Jandeson Brasil, Vera Huszar*

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Understanding the processes that shape the biological communities in different environmental gradients has been a challenge in ecology and conservation sciences. Taxonomic diversity indices are traditionally used for understanding these processes, but they do not consider the functional differences of the species. Functional diversity can provide information on the subjacent mechanisms in structuring communities, including how species are functionally complementary or redundant. In this study we evaluate whether qualitative and quantitative indices of functional diversity are more strongly related to habitat conditions than taxonomic diversity. For this, we estimated a taxonomic diversity index (TD, species richness) and the three components of the functional diversity (FD.PG = functional diversity Petchey & Gaston index; FDis = functional dispersion; FEve = functional evenness), based mainly on morphological traits (maximum linear dimension, surface area:volume ratio of organisms, heterocytes, silica wall, life forms, mucilage, aerotopes, flagella) and pigments. We also evaluated the functional redundancy (FR) as the difference of the Gini–Simpson index of species diversity and Rao's quadratic entropy. If FR=0 the species have completely different traits; if FR=1, all the species have identical traits. Furthermore, we analyzed the relationships between qualitative (TD and FD.PG) and quantitative indices (FDis and FEve) of phytoplankton versus environmental gradients (morphometric, hydrological, mixing, resources - light, nutrients and grazing pressure), through generalized linear models (GLM) in eight

tropical and subtropical reservoirs, widely distributed in Brazil (255 samples). We found a total of 469 morphospecies; ~40% occurred only in two samples. Higher qualitative indices, both taxonomic (TD) and functional (FD.PG), were found in Amazonian reservoirs, but this pattern was not observed for quantitative indices (FDis and FEve). Taxonomic diversity was more strongly correlated to the environmental predictors (D2 = 55%), both abiotic (temperature, residence time, total nitrogen) and biotic (grazing pressure) than the qualitative and quantitative functional diversity indexes (D2 = 2.6-25%). Contrary to our expectation, taxonomic diversity appeared as a good measure to better understand the phytoplankton diversity across environmental gradients in our reservoirs, probably because the species perform similar functions in the ecosystems, as shown by the intermediate (0.5-0.6) and high functional redundancy index (0.7) in our reservoirs.

28-O   Complexity of interactions – what we know about phenotypic plasticity in *Desmodesmus*?

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Phenotypic plasticity is the ability of a single genotype to produce several different physiological and/or morphological types under changing environmental conditions. Many organisms have the ability to modify their morphology according to their environment. In the case of aquatic organisms, they can modify their phenotype as a response to abiotic (water chemistry) and/or biotic (e.g. predator pressure) factors. Many of the strains/species of Desmodesmus exhibit extensive phenotypic plasticity alternating between colonies and unicells and/or spiny and spineless forms. It has been well documented that some species of Desmodesmus produce spiny colonies when nutrient availability is low, whereas unicells are produced when phosphorus or nitrogen are elevated. Colonies and unicells become spineless when iron availability is low or lacking. There is also some evidence that changes from unicell to colony are due to the presence of predators, e.g. Daphnia. Conducting laboratory experiments provides information that can help us to explain the mechanisms of phenotypic plasticity. However, the problem arises when we want to understand the whole ecosystem, because it is complex. In our investigations, we have approached the problem both ways: experiments in the laboratory and direct observations in the field. Field observations proved that phenotypic plasticity occurred in some Desmodesmus species, but it was difficult to say which factor (abiotic or biotic) was the most important for triggering those changes. For example, laboratory experiments showed that D. abundans CCAP 258/299 exhibited a higher percentage of spiny unicells (up to 40%) in highly eutrophic waters. On the other site, spiny colonies dominated in the waters with lower nutrient concentrations. Very short spines were found in specimens with high iron concentration. In cultures with a lower concentration of nutrients (especially nitrogen), almost 100% colonies were formed by day 6. Our conclusion is that solving the conundrum of phenotypic plasticity in nature, we should think more about the complexity of factors such as abiotic+biotic than only a single parameter. Furthermore, we think that phenotypic plasticity might be a useful marker as a bio-indicator of abiotic or biotic change in nature.

29. BIOGEOCHEMICAL CYCLE OF MERCURY: FROM THE MOLECULE TO THE ECOSYSTEM

29-O   Mercury cycle in hydroelectric boreal reservoirs in Québec, Canada.   *François Bilodeau, Alain Tremblay*

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At the La Grande hydroelectric complex located in northern Québec, Canada, the evolution of mercury (Hg) was monitored for over 35 years in natural and modified environments. Hg and methylmercury (MeHg) measurements were carried out in soil, sediment and biota (plankton, insects, fish) to better understand the processes involved in the mercury cycle and ultimately, understand and predict the impact of hydroelectric reservoirs. Impoundment of reservoirs leads to the conversion (Hg to MeHg) and circulation of Hg already present in plants and flooded soil in the aquatic environment. This organic form, MeHg, is easily accumulated by living organisms, from plankton and aquatic insects to fish that can be consumed by humans. In reservoirs, concentrations in all fish species increased rapidly after impoundment, peaking after 5 to 13 years in non-piscivorous species, and after 9 to 14 years in piscivorous species. These concentrations increase at levels 2 to 8 times higher than those measured in surrounding natural lakes. Depending on the reservoir, the return to levels found in fish of natural surrounding lakes was completed after 10 to 20 years for non-piscivorous species and after 20 to 31 years in most piscivorous species. Contamination of the food chain is mainly explained by changes in the Hg form present in soil after impoundment. The progressive methylation of initial inorganic Hg content increased from 1% in natural soil and up to 30% after 13 years of flooding. The following mechanisms appear to be most important in the increasing mercury level in fish: 1) increased bacterial methylation of Hg and its passive diffusion through the water column; 2) erosion of flooded organic matter in the drawdown zone, which makes fine, Hg-rich organic particles available for aquatic filter feeders, and active transfer of Hg by aquatic insects burrowing in flooded soil rich in MeHg; 3) periphyton development on flooded soils and vegetation, which promotes the methylation of Hg and its active transfer to fish via aquatic insects and zooplankton feeding on it. The increased MeHg production generally ends 8 to 10 years after impoundment due to rapid depletion of the readily decomposable elements of flooded soil and vegetation. After this time, MeHg transfer to fish by periphyton, zooplankton and insect larvae is reduced to levels occurring in natural lakes.

29-O   Climate change and mercury in the Arctic: the case of permafrost thaw ponds.   *Marc Amyot [1] - Gwyneth MacMillan [1] - Catherine Girard [1] - Maxime Leclerc [1] - John Chételat [2] - Isabelle Laurent [3]*

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Permafrost thaw ponds are ubiquitous in the eastern Canadian Arctic, yet little information exists on their potential as sources of methylmercury (MeHg) to freshwaters. MeHg is a potent neurotoxin that can biomagnify to elevated concentrations in aquatic food webs. Thaw ponds are microbially-active and conducive to methylation of inorganic mercury, and are affected by changes in nutrient inputs related to Arctic warming. This multi-year study investigates thaw ponds in a discontinuous permafrost region in the subarctic taiga (Kuujjuarapik-Whapmagoostui, QC) and a continuous permafrost region in the Arctic tundra (Bylot Island, NU). MeHg concentrations in thaw ponds were well above levels measured in most freshwater ecosystems in the Canadian Arctic. On Bylot, ice wedge trough ponds showed significantly higher MeHg ($0.3 - 2.2$ ng L^{-1}) than polygonal ponds ($0.1 - 0.3$ ng L^{-1}) or lakes (< 0.1 ng L^{-1}). High MeHg were also measured in the bottom waters of subarctic thaw ponds near Kuujjuarapik ($0.1 - 3.1$ ng L^{-1}). High water MeHg in thaw ponds were strongly correlated with variables associated with high inputs of organic matter (DOC, a320, Fe), nutrients (TP, TN), and microbial activity (dissolved CO_2 and CH_4). Further, through a combination of *in vitro* and *in situ* experiments, we examined MeHg photodegradation potentials in high-dissolved organic matter (*DOC*) thaw ponds on Bylot Island and a low-*DOC* oligotrophic lake on Cornwallis Island (Char Lake). In Bylot, the ambient MeHg photodemethylation (PD) rate over 48 h of solar exposure was of 6.1×10^{-3} m^2 E^{-1}, and the rate in MeHg amended samples was 9.3×10^{-3} m^2 E^{-1}. In contrast, in low-*DOC* Char Lake, PD was only observed in the first 12 hours which suggests that PD may not be an important loss process in polar desert lakes. Thiol addition slowed (thioglycolic acid) or had no impact (glutathione) on PD rates. Chloride addition did not impact PD potential in *in situ* experiments. During an

ecosystem-wide experiment conducted in a covered Bylot pond, there was neither net MeHg increase in the dark nor loss attributable to PD following re-exposure to sunlight.

Overall, our results suggest a relationship between organic matter erosion from thawing permafrost, reducing conditions in the sediments, and the production of methylmercury in these sites. Thawing permafrost due to Arctic warming will continue to release nutrients and organic carbon into these systems and increase ponding in some regions, likely stimulating higher water concentrations of MeHg. Greater hydrological connectivity from permafrost thawing may potentially increase transport of MeHg from thaw ponds to neighbouring aquatic ecosystems. We further propose that high-DOC Arctic thaw ponds are more prone to MeHg PD than nearby oligotrophic lakes. However, at the ecosystem level, these ponds remain likely sources of MeHg for neighbouring systems.

29-O   Periphyton communities as a tool to assess mercury impact on surface water.   *Séverine Le Faucheur, Perrine Dranguet, Aline Freiburghaus, Carmen Moinecourt, Vera I. Slaveykova*

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Periphyton communities are an assemblage of microorganisms living in shallow waters which possess a variety of characteristics to be a good bioindicator, i.e. abundant, easy to collect, integrate the quality of its ambient environment and sensitive to pollutants. Our work investigated whether periphyton could be used as a bioindicator of mercury (Hg) effects on natural waters and explored the interconnections between Hg concentrations, bioaccumulation and periphyton composition. To that end, field- and lab-based experiments were performed with periphyton grown on artificial substrata in either Hg-impacted waters and in microcosms spiked with Hg. The field experiments were performed in contrasted environments: the Olt River (Romania) impacted by effluents from a chlor-alkali platform and the lagoon of Venice (Italy) affected by urban, industrial or agricultural releases. To get further mechanistic insights on the Hg-periphyton interactions, the field studies were complemented by microcosm experiments using Geneva Lake water enriched with environmental concentrations of Hg (6 pM to 0.9 nM). Bioaccumulated inorganic Hg (Hg^{II}) and methylmercury (CH_3Hg) in periphyton were measured w/o cysteine washing to assess the total and intracellular Hg content. Periphyton composition was examined from gene to community levels using several techniques, notably qPCR, epifluorescent microscopy and pyrosequencing. In parallel, the physico-chemical parameters of the ambient waters (pH, anion/cation and dissolved organic matter concentrations) were well characterized and Hg^{II} and CH_3Hg concentrations measured in order to predict dissolved Hg^{II} and CH_3Hg speciation. Commercially available Diffusive Gradients in Thin Films (DGT) for Hg were additionally used in the lagoon of Venice. The main findings of the study can be summarized as follows: (i) accumulation of Hg^{II} in periphyton correlates with specific dissolved Hg species ($Hg(OH)_2$ and $Hg(CO_3)_2$) concentrations as well as with the abundance of *merA* and *hgcA* genes, (ii) Hg^{II} exposure at environmental low concentrations (pM levels) induce a shift in periphyton composition, favoring bacteria over algae and (iii) CH_3Hg accumulation in periphyton could not be linked with any studied chemical or biological factors, except with the abundance of 16S gene. Our results show promising avenues to use periphyton as an indicator of Hg effects towards aquatic systems.

29-O   Influence of organic matter composition on mercury methylation in aquatic ecosystems.

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One major challenge in contemporary environmental science is to identify factors controlling the formation of methylmercury (MeHg). The formation of MeHg is biotically mediated in aquatic systems. Organic matter (OM) interacts very strongly with Hg, affecting its speciation, solubility, mobility, and toxicity in the aquatic environment. OM in aquatic systems consists of a mixture of terrestrial compounds drained from the catchment and internally produced OM mainly derived from phytoplankton. Even if the effect of OM concentration on Hg methylation has been the subject of numerous studies, the influence of the molecular composition of OM remains poorly understood. Here we show the impact of terrigenous and planktonic derived OM on Hg methylation in different aquatic ecosystems. Concretely, we studied Hg methylation in sediments of 10 lakes and 9 beaver pond ecosystems. While the selected lakes receive inputs of both terrigenous and in situ OM, the sediments from beaver ponds of different ages are primarily dominated by terrigenous OM with different degradation status. We used inorganic mercury isotope tracers to determine mercury

methylation and pyrolysis–gas chromatography mass spectrometry to identify and quantify 111 organic compounds in lakes sediments. We used optical measurements (spectrometry and fluorescence) to characterize the OM in the sediment overlying water of beaver pond ecosystems. Hg methylation rate constants reach the highest values in lakes dominated by protein algal derived compounds (0.038–0.075 day^{-1}, n=4) and are much lower in lake sediments enriched in terrigenous OM (0.0095–0.013, n=5) or in invertebrate chitin associated compounds (0.013, n=1). For sediments in the beaver ponds, we found a median of 0.026 day^{-1} (IQR=0.01–0.031, n=9). The characterization of OM suggests that, in lake sediments, algal-derived compounds (i.e. 2.5-diketodipiperazines, phytols, phytenes) primarily control Hg methylation by enhancing the activity of the whole microbial community. Indeed, the sediment ratio of phytol to lignin as a proxy for the relative contribution of external and internal organic matter sources correlated positively with Hg methylation rate constants (p-value<0.05). In beaver ponds, chlorophyll-a also correlated with Hg methylation rate constants, confirming the role of algal derived OM even in systems dominated by terrestrial sources. Qualitative analysis of the sediment overlying dissolved organic matter with excitation-emission-matrix fluorescence spectroscopy, further suggests that unprocessed terrestrial organic matter also enhances Hg methylation in young pounds. We thus conclude that algal derived compounds are the main driver of Hg methylation, but in systems limited by autochthonous sources, fresh terrigenous OM play an important role on the process.

29-O Mercury accumulation and effects on surface and benthic periphyton. *Perrine Dranguet [1] - Séverine Le Faucheur [1] - Sylvain Bouchet [2] - Maxime Leclerc [3] - David Amouroux [2] - Marc Amyot [3] - Vera I Slaveykova [1]*

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Periphyton are a melting pot of microorganisms (microalgae, bacteria, fungi…) which live interlocked in a exopolymeric substances (EPS) matrix. In running waters, they represent one of the entry points of mercury (Hg) into food chains. The present study aims to understand Hg accumulation processes and impacts in periphyton under chemically controlled conditions. Vertical artificial substrata were placed in the Versoix River (Switzerland) to be colonized by periphyton. After 3 months, two distinct populations could be visually distinguished depending on the exposure light, and which were qualified as surface and benthic periphyton. Both periphyton were exposed to 93 ± 26 pM of ^{199}Hg during 72h (T72) using microscoms and examined for their Hg content (total Hg and non-extractable Hg e.g. after a washing step with cysteine) as a function of the exposure time. Their composition was also analyzed with the characterization of their thiols (colloidal and capsular fractions) in their EPS fractions as well as with the measurements of their chlorophyll a content and ash-free dry weight. Physico-chemical parameters of the exposure water i.e. pH, anion/cation, dissolved organic matter (DOM), dissolved inorganic and organic Hg concentrations were measured at the beginning (T0) and the end of the exposure (T72) in order to model Hg speciation. Benthic periphyton were found to contain two times more inorganic particles than surface periphyton whereas no difference in chlorophyll a content was measured between both biofilms. A difference was also observed in the EPS fractions with more capsular but less colloidal thiols in benthic periphyton than in surface periphyton. Upon exposure to Hg, total and non-extractable Hg contents increased linearly with the exposure time in both periphyton. The concentrations of total Hg content in surface periphyton were 24 ± 2 pmol g$_{dw}^{-1}$ at T0 and 771 ± 227 pmol g$_{dw}^{-1}$ at T72 whereas total Hg content was 7 times higher in benthic periphyton with 180 ± 10 pmol g$_{dw}^{-1}$ and 5065 ± 1128 pmol g$_{dw}^{-1}$ at T0 and T72, respectively. The proportion of the non-extractable Hg content (~25%) was similar in both periphyton at T72. Exposure to Hg also induced a decrease of chlorophyll content in both periphyton, suggesting a high impact on the algal fraction. The EPS were also affected by Hg with a large decrease of the colloidal thiol (5 times) and capsular thiol (11 times) concentrations in the surface and benthic periphyton, respectively. Hg exposure was thus found to impact the algal fraction as well as the quality of EPS. Further analysis, notably on Hg content in thiol fraction and genetic periphyton composition, will be performed to assess the link between composition and accumulation.

29-O Trophic chain and mercury transfer in fish. *Jean Therrien [1] - François Bilodeau [2]*

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At several hydroelectric complexes located in northern Québec, Canada, the evolution of mercury (Hg) in natural and modified environments was monitored over several decades. Hg was measured in fish to evaluate the consumption risk

for humans, make temporary consumption recommendations, and ultimately understand and predict the impact of hydroelectric reservoirs on mercury levels in fish. In reservoirs, concentrations of Hg in all fish species increased rapidly after impoundment, but peak levels and increase factors in the same species varied depending on reservoirs characteristics as well as on fish assemblage. Northern pike, a piscivorous species at the top of the food chain, had background levels similar in the Eastern Sector (0.55 ppm) and Western Sector (0.59 ppm) reservoirs of the La Grande Complex. But the peaks and increase factors were different for 700-mm northern pike: 1.65-2.73 ppm and 3.0-5.0 fold increases in the Eastern Sector compared to 2.77-4.66 ppm and 4.7-7.9 fold increases in the Western Sector. There were differences in physical characteristics, which can explain the variations between reservoirs of the same sector, but the major biological factors explaining the differences between sectors are the fish species present in the fish community and their diet. In the Eastern Sector, on average, the northern pike's stomach content biomass includes coregonidae (54%), with whitefish being the only species and showing peaks between 0.33 and 0.48 ppm, while piscivorous fish represent less than 1% of the diet. In the Western Sector, piscivorous fish are the leading prey (49%), including 400-mm walleye with peaks between 2.07 and 2.82 ppm, followed by coregonidae (29%), including cisco with peaks at 1.10 ppm (10 fold increase for 150-mm fish), two species not present in the Eastern Sector.

29-O   Methylmercury accumulation on periphyton biofilms in relation to watershed disturbances in the boreal landscape.   *Dolors Planas*

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Hg derived from atmospheric deposition accumulates in rich organic soils and is adsorbed on dissolved organic carbon (DOC). Hg bound to DOC is exported to aquatic systems where it is transformed to the toxic and biomagnifiable form, the methylmercury (MeHg). Remote watersheds that are naturally perturbed by river dams (beavers and humans) and other rapidly expanding human activities such as logging, release new Hg into the aquatic system leading to methylation in the periphyton biofilms. The few existing data on mercury concentration on periphyton biofilms have demonstrated high MeHg accumulation that in the pelagic milieu in naturally and human perturbed watersheds. Periphyton biofilms are usually ignored as an important Hg-source in aquatic food web and are rarely taken in account in the biogeochemical cycle of mercury. Periphyton biofilms living in the land-water interface, directly receive and process runoffs where solutes are less diluted than in the pelagic zone. Thus, they respond faster to contaminants and may be an early warning of MeHg concentrations at the base of the food web. Our aim is to verify the importance of logging as a key driver that increases the export of DOC and Hg to lakes and to assess the role of periphyton biofilms as bio-accumulators of MeHg using a meta-analysis of boreal lakes data. The set of lakes will cover a perturbation range of logging from 0 to 80 % of the watershed. We will include in the analysis several intrinsic variables that could modulate Hg availability in aquatic ecosystems such as pH (low pH/high Hg in the biota), % wetland in the watershed (affect export of Hg), watershed morphometry (e.g., slope influence COD and phosphorus export), temperature (modifies metabolic rates and methylation and demethylation rates) and nutrients. In logged watersheds, nutrients could indirectly affect MeHg bioaccumulation by regulating biofilm biomass.

29-O   Effect of recent artisanal small-scale gold mining ASGM in Kedougou region on mercury and methylmercury contamination of soil, sediment, water and biota of the Gambia River (Senegal).
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In eastern Senegal, in the region of Kedougou, increasing artisanal small-scale gold mining (ASGM) activities using mercury (Hg) for gold amalgamation have been recorded since 1995. The main objective of this study is to determine the environmental impact of the use of mercury in order to assess the potential risk of Hg exposure for the local population, the mechanism of mercury methylation and mercury biomagnification in the food web of Kedougou region. Sediments, soil, water, and biota samples were collected along the Gambia River and local water pond of the Kedougou region and analysed for total mercury concentration (THg) and methylmercury (MeHg). THg and MeHg were analysed respectively by AAS after catalytic decomposition and gold amalgamation and GC-separation and thermo-decomposition by fluorescence 153 spectrometer (GC-CVAFS, Merx BrooksRand). Quality (QA/QC) was checked using certified 154 reference materials (i.e. Mess-3; National Water Research Institute, Canada).

Our study reveals the presence of higher amounts of concentrations of elemental mercury (Hg^0) in comparison the soluble + exchangeable Hg fraction, suggesting that Hg behaves as a nearly immobile component in the soil of sampling sites affected by ASGM activities. The results highlight the high concentration of total Hg concentration (9.93 mg.kg^{-1}) measured in sediment cores sampled in the vicinity of ASGM operations. The comparison of THg sediment concentrations at different sites with the values of sediment quality guideline developed by MacDonald et al (2000) shows that: the main active ASGM sites have concentrations above the probable effect concentration (PEC) of THg and are therefore likely to cause probable effects of fish fauna. Our study documents that concentrations of total and dissolved Hg and methylmercury (MeHg) are very high. It also shows that Hg discharged and transported from ASGM sites is susceptible to methylation for MeHg formation, which is toxic for biota. Based on their diet habit, the lowest and the highest concentration in fish were found in the herbivorous and piscivorous groups respectively, primary consumer including (Sarotheron melantheron) and highest in secondary consumers (omnivorous and piscivorous). THg in mollusc species caught in sampling site affected by ASGM is higher than the concentration of molluscs from site devoid of ASGM activities. Stable isotope ($\delta^{13}C$) analysis indicated that fishes and molluscs species had contrasting feeding niches, which may also affect the Hg accumulation.

29-O   Deciphering two uncertainties in mercury chemical transformation processes: development of chemical speciation techniques and the effect of heterogeneous reactions.   *Parisa Ariya, Avik Ghosdastidar, Lin Si, Daniel Deeds*

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Mercury is known to humanity for several millennia. It has been used in numerous fields including medicine, catalysis, optics, and green technology. Yet, mercury compounds are also known for being persistent, toxic and for being bio-accumulative pollutants of global interest. Volatile mercury species exist in the atmosphere, and undergo (photo) chemical transformation. Upon deposition, predominantly oxidized mercury species can deposit on the Earth's surface and potentially be bio-accumulative in the aquatic food chains. Since the atmosphere is an efficient medium for mercury transformation, (photo)chemical homogenous and heterogeneous reactions can occur at atmospheric interfaces such as aerosols, fog, snow-air, and vegetation-air. However, the detailed mechanisms responsible for such transformations are not fully understood. In this talk, we will address two major gap of knowledge. The first critical gap in the current understanding of mercury cycling in the environment arises from the inability to directly study the chemical speciation of mercury in air. We have developed a novel technique wherein gaseous oxidized mercury species are analysed using pre-concentration on nano-adsorbents coupled to soft ionization mass spectrometry and electrospray chemical chemical ionization mass spectrometry. The technique preserves the chemical identity of mercury species typically lost to fragmentation in traditional mass spectrometric analysis. Initial result using this methodology for both atmospheric and aquatic media will be presented, and the strengths and limitations of the technique will be assessed through comparison to current methods used to measure the bulk speciation of mercury in air and water/snow. The second thrust of this talk, will address heterogeneous chemistry in aquatic phases. Despite direct and indirect evidence suggesting that heterogeneous surfaces potentially play a key role in mercury chemistry, there is little known about mercury reactions and equilibrium processes that take place. The lack of knowledge of mercury surface chemistry is a major gap for adequate modeling of mercury cycling. We will provide recent data on the photoreduction of $Hg^{2+}_{(aq)}$ in the presence of various alkanethiols and thioglycolic acid ($H\text{-}SCH_2COO\text{-}H$) used as model compounds for DOM. We will also discuss the formation of nanoparticles such as $HgS_{(s)}$ nanoparticles, comparable in structure to metacinnabar. We will discuss the impact of such (photo)chemical heterogeneous reaction in mercury cycling in selected aquatic environments.

29-O   Bioaccessibility of MeHg from fish: the role of the Inuit diet and microbiome.   *Catherine Girard* [1] - *B. Jesse Shapiro* [2] - *Marc Amyot* [1]

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The Arctic is a sink for mercury (Hg) that is emitted at lower latitudes and transported through the atmosphere. Once deposited, Hg can be transformed into methylmercury (MeHg) and accumulate and biomagnify through foodwebs. Because of its reliance on fish and marine mammals, the traditional Inuit diet can expose its practitioners to high levels

of MeHg, making Hg a major health issue in the North. Recent studies have shown that current pharmacokinetic models aiming to predict the effects of Hg on humans are unable to properly describe the Inuit. This suggests that genetic, cultural or environmental factors may play a role in absorbing Hg. The objective of this study is to identify what factors can alter Hg absorption in the Inuit of Resolute Bay (Nunavut).

Here, we show that culinary practices from the Inuit traditional diet, identified through dietary habit questionnaires, can impact MeHg bioaccessibility from fish. Various cooking techniques including grilling, frying and boiling reduced MeHg bioaccessibility by 51-55% when compared to raw fish. Freezing, which is a common practice in Northern communities, reduced bioaccessibility by approximately 15% after 48 hours, with no differences between -20 and -80°C treatments. We also tested the effects of co-ingested foods rich in phytoelements. Tea and coffee reduced bioaccessibility by 28-40%, to varying degrees according to brands. Blueberries, which are also rich in phytoelements, had no significant impact on bioaccessibility. We confirmed the role of certain specific phytoelements by testing isolated compounds. Cooking treatments and co-ingested foods had a combined effect greater than their individual impacts. Therefore, dietary practices can alter the solubilisation of Hg in the gut, limiting its absorption by the body.

We also investigated the role of the gut microbiome in Hg metabolism in the gut, using stool samples donated by Inuit participants. Deep sequencing of the bacterial 16S rRNA gene revealed subtle differences between the Inuit and a group of participants from temperate latitudes with a western diet. Strain-level variations between both groups were attributable to geography and diet. We are currently using shotgun metagenomic sequencing and PCR assays to understand the function of the Inuit microbiome in Hg metabolism, in terms of the distribution of bacterial genes involved in Hg cycling.

We conclude that culinary practices can alter bioaccessibility of MeHg from fish, which is the main source of Hg exposure in humans. Meanwhile, better knowledge of the microbiome may contribute to improving pharmacokinetic models for Hg in Inuit populations. These results further our understanding of the fate of food-borne Hg in the human body.

29-P   Uptake and effects of mercury compounds to phytoplankton: from the molecule to the cell.

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Mercury biogeochemical cycle is strongly affected by the human activities, resulting in a significant increase of Hg compounds concentrations in the environment. What is more, Hg compounds bioconcentrate in biota, biomagnify along the food web and ultimately represent serious concern for the environmental and human health. The present work focusses on the interactions of Hg compounds with phytoplankton. Phytoplankton is a major primary producer in surface water and important entry point of Hg compounds in the food webs. The specific objective of the present study was to explore the interactions of inorganic mercury (IHg) and methylmercury (MeHg) with green algae *Chlamydomons reinhardtii* at molecular and cellular level. To this end the transcriptomic and physiological responses of *C. reinhardtii* to short-term exposure to a large concentration range of IHg (0.1 to 100nM) and MeHg (50pM to 50nM) were studied, together with determination of intracellular Hg contents. The tested physiological endpoints included growth, oxidative stress and photosynthesis efficiency. RNAseq, next generation sequencing technology, was used to examine mercury-induced perturbations of cellular metabolic pathway and to detect the earliest stages of the toxicological response. Obtained results demonstrated an increase of the intracellular Hg and MeHg contents with the concentration in the exposure medium. The number of up- or down- regulated transcripts increased with the intracellular Hg contents of both IHg and MeHg. For comparable intracellular content, the number of the dysregulated transcripts was higher for MeHg than for IHg supporting stronger impact of MeHg on algae as compared to IHg. Exposure to MeHg dysregulated the expression of genes involved in motility, energy metabolism, lipid metabolism, and transport and antioxidant enzymes, while IHg induced similar alterations but only at highest exposure concentration. MeHg induced increase of the percentage of the cells experiencing oxidative stress, while no oxidative stress was detected for IHg exposure. The expression of several metal transporters' genes (e.g. Cu, Co, Zn) was affected by both species, showing that they might be involved in a transport of Hg within the cells. The results of this basic research contribute to significant improvement of the understanding of Hg compounds uptake mechanisms and the adverse outcome pathways in green algae, a model of aquatic primary producers, as well as to the development of sensitive genetic biomarkers in support to biomonitoring efforts of mercury monitoring programs in aquatic systems.

29-P   Mercury bioaccumulation and fatty acid profiles in Swedish and Chinese lake food webs.

Pianpian Wu [1] - *Haiyu Yan* [2] - *Martin Kainz* [3] - *Kevin Bishop* [1] - *Staffan Åkerblom* [1] - *Min Jing* [4]

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Fish is the major exposure route of mercury (Hg), as well as an important dietary source of long-chain polyunsatured fatty acids (PUFA) to humans and wild life. The Swedish fish Hg concentration (>0.5 mg kg^{-1} wet weight (w.w.) in >50% of lakes, >99% as methylmercury (MeHg) in 1kg pike (*Esox lucius*)) contrasts enormously with the ones identified in China (<0.3 mg kg^{-1} w.w. in almost all fishes, e.g.common carp (*Cyprinus carpio*)), though the differences of MeHg in the environment are less pronounced (aqueous MeHg concentrations in Sweden: 0.04-0.8 ng L^{-1} versus China: 0.03-3 ng L^{-1}). We measured Hg, MeHg, and PUFA concentrations in surface water, plankton, benthic fauna, and fishes sampled from 7 freshwater lakes in Sweden and 6 reservoirs in China. We also include MeHg bioaccumulation and PUFA profiles in different plankton size groups: seston (<25 µm in Sweden), microplankton (64-112 µm in China; 25-100 µm in Sweden), mesozooplankton (112-500 µm in China; 100-500 µm in Sweden) and macrozooplankton (>500 µm in Sweden). This novel comparison and evaluation of MeHg bioaccumulation and PUFA retention patterns across lake food webs in Sweden and China will be presented as part of the Sino-Swedish Mercury Research Framework (SMaRef).

30. FROM PICOCYANOBACTERIA TO COLONIAL CHROOCOCCOID CYANOBACTERIA: ECOLOGICAL AND PHYLOGENETIC ASPECTS

30-O   Genetic diversity and niche adaptation in marine picocyanobacteria: a genomic and metagenomic perspective.   *Laurence Garczarek* [1] - *Hugo Doré* [1] - *Gregory K. Farrant* [1] - *Francisco M. Cornejo-Castillo* [2] - *Florian Humily* [1] - *Morgane Ratin* [1] - *Antoine Bisch* [3] - *Frances D. Pitt* [4] - *Martin Ostrowski* [5] - *David J. Scanlan* [4] - *Silvia G. Acinas* [2] - *Frédéric Partensky* [1]

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Prochlorococcus and *Synechococcus* are the two most abundant and widespread oxyphototrophs of the ocean. Although these two genera generally co-occur, *Prochlorococcus* dominates in warm, oligotrophic areas from 40°S to 45°N, while it is often outcompeted by *Synechococcus* in coastal and mesotrophic waters. In order to better understand the factors controlling their respective phylogeography, we sequenced 32 strains belonging to the marine *Synechococcus/Cyanobium* radiation, an effort that more than doubled the number of currently available genomes in public databases and nicely complemented the existing dataset in terms of genetic and pigment diversity. Extensive comparisons of 53 *Synechococcus* and 28 *Prochlorococcus* genomes allowed us to considerably refine the core and pan-genomes at various taxonomical levels. Heatmaps of pairwise ANI between all 81 genomes demonstrated that according to the 94% ANI identity criteria, most sub-clades IIIa members would belong to the same species, (and this also holds true for members of clade V and subclade VIIa), while every single other *Synechococcus* strain would constitute a distinct species, even within a given subclade.
In complement to these comparative genomic analyses, we also analyzed 109 metagenomes from the *Tara* Oceans expedition by recruiting reads targeting the high resolution taxonomic marker *petB*, encoding cytochrome b_6, using a $_{mi}$Tag approach. These analyses unveiled a previously unsuspected genetic diversity within both *Prochlorococcus* and *Synechococcus* genera. By delineating Ecologically Significant Taxonomic Units (ESTUs), i.e. genetically related organisms occupying a given oceanic niche, based on the distribution patterns of picocyanobacterial communities, we identified three major *Prochlorococcus* assemblages along the cruise transect and eight for *Synechococcus*. Analyses of the biogeography of these ESTUs also revealed that there was a remarkable correlation between these assemblages and specific environmental cues and that picocyanobacterial communities of the Pacific Ocean were drastically different from those of other oceanic regions. Sharp community shifts were also observed over short geographic distances, e.g. around the Marquesas Islands or between southern Indian and Atlantic Oceans, pointing to a tight correlation between ESTU assemblages and specific physico-chemical parameters. Altogether, our study demonstrates that *petB*-ESTUs provide a much finer prediction of picocyanobacterial 'ecotypes' than do phylogenetic clades, bringing novel insights into the ecology, diversity and biology of the two most abundant phototrophs on Earth.

30-O   Comparative genomics and phylogenetic analyses of non-marine picocyanobacteria.   *Patricia Sánchez-Baracaldo* [1] - *Nathan A. M. Chrismas* [1] - *Andrea Di Cesare* [2] - *Cristiana Callieri* [2]

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Picoplanktonic cyanobacteria contribute up to 80% of the total primary production in lakes, depending on the season, water chemistry and hydrography. While picocyanobacteria play a key in role as primary producers in lake systems worldwide, little is known about their genomic structure or phylogenetic relationships. Large-scale multi-gene (135 proteins and two ribosomal RNAs, SSU and LSU) phylogenetic analyses have confirmed that freshwater picocyanobacteria, including *Cyanobium* and *Synechococcus*, are sister to marine *Synechococcus* and *Prochlorococcus*; both clades diverged from a freshwater single cell cyanobacteria ancestor. We sequenced the genomes of eight strains of non-marine picocyanobacteria including localities from Europe, South and Central America. Comparative genomics show, for the first time, that picocyanobacteria could possess the genetic machinery necessary to perform nitrogen

fixation as revealed by two strains such as LL (L. Albano) and 3B3 (L. Candia). Highly reduced genomes (genome streamlining) seem to be characteristic of strains from ultraoligotrophic lakes such as 1G10 (L. Nahuel Huapi); a similar trend has been observed in marine *Prochlorococcus*. Five strains (8F6 L. Alchichicha, 6H9 L. Atexcac, LL L. Albano, 3B3 L.Candia and 1G10 L. Nahuel Huapi) contain the red pigment phycoerythrin and include the first examples of complete genomes containing Type IIB phycoerythrin clusters previously identified in cyanobacteria from the Baltic Sea. Phylogenetic evidence supports the idea that these genes pigment may have been acquired via lateral gene transfer from marine lineages.

30-O   The revision of phylogenetic relationships of some freshwater picocyanobacteria. *Iwona Jasser* [1], *Jan Kwiatowski* [2]

Department of Microbial Ecology and Environmental Biotechnology, University of Warsaw, Poland [1], *Department of Molecular Phylogenetics and Evolution, University of Warsaw, Poland* [2]

Picocyanobacteria are the smallest primary producers in aquatic ecosystems. They are ubiquitous in marine and freshwater ecosystems, where together with heterotrophic bacteria serve as a base for microbial food webs. The occurrences, abundance, productivity of picocyanobacteria and their phylogenetic relationships have been studied intensively in various environments. While picocyanobacteria contribute substantially to the primary production (PP) in the marine ecosystems, their share in PP in freshwaters, especially in eutrophic environments is much smaller. Nevertheless, the variety of environments in which picocyanobacteria have been found in freshwaters is astounding, suggesting high diversity of these microorganisms. In freshwaters single-celled picocyanobacteria are mainly represented by two genera: Synechococcus and Cyanobium, of which Synechococcus has been considered polyphyletic. The phylogenetic analyses have shown that besides the positions of the Synechococcus and Cyanobium clades, many Synechococcus strains are intermixed with various picocyanobacteria. We have conducted phylogenetic analysis of over 200 sequences of rRNA operon, including sequences of 16S rRNA, tRNA-Ala, tRNA-Ile, 23S rRNA genes and internal transcribed spacer (ITS1) retrieved from GenBank. In this way we reviewed the phylogenetic positions of particular strains, which were previously claimed to belong to the endemic group M from Mazurian lakes. We also verified relationships between cosmopolitan groups, such as Group A (a Cyanobium gracile cluster), Group B (subalpine cluster I with Synechococcus rubescens), Group E (with Lake Biwa strains) and Group C/Cz (with strains firstly isolated from Czech lakes). Our analysis suggests that the Groups M and B are distantly related. The analysis confirmed also the position of two strains KS0807 and SM0807, isolated from two low-pH lakes in Poland, as belonging to Group B and Group A, respectively.

30-O   Control factors and ecological role of autotrophic picocyanobacteria in a meromictic karstic lake. *Antonio Camacho, Antonio Picazo, Carlos Rochera, Maria Rosa Miracle, Eduardo Vicente*

Cavanilles Institute of Biodiversity and Evolutionary Biology, University of Valencia, Burjassot, Spain

The factors that control the abundance and relative dominance of cyanobacteria in aquatic ecosystems have been extensively studied in both saltwater and freshwater ecosystems. Freshwater ecosystems show significant trophic gradients and diversity of environments and the relative relevance of cyanobacteria shifts from unicellular species in oligotrophic waters to filamentous or colonial species at higher trophic levels. In this work we studied different mechanisms that explain the dominance of autotrophic picocyanobacteria (Pcy), as well as the factors controlling their abundance and the ecological consequences of this dominance, in the model Lake La Cruz. This is a small, deep, meromictic lake, which additionally shows a strong seasonal thermal stratification, presenting a permanent carbonate oversaturation with the occurrence of annual whiting events. A sharp thermocline seasonally develops from April to October with the development of a highly productive deep chlorophyll maximum (DCM). The main photosynthetic microorganisms in the lake are autotrophic picocyanobacteria (Pcy), larger eukaryotic phytoplankton, and photosynthetic sulfur bacteria. Despite the diversity of photosynthetic microorganisms found in Lake La Cruz, Pcy dominate over the limnological cycle both in biomass and in the relative contribution to inorganic carbon assimilation. Maximum Pcy abundance of up to 14×10^6 cells ml^{-1} was found, although the rest of photosynthetic microorganisms can also be seasonally significant in terms of biomass. Oxygenic photosynthesis is the most important process of inorganic carbon assimilation accounting for 89.7% (164 g C m^{-2} yr^{-1}) of total inorganic carbon assimilation, where Pcy are responsible of 80% of this assimilation. Anoxygenic photosynthesis accounts for 2.7% and chemolithoautotrophy for 7.6% of the total inorganic carbon assimilation. Different bioassays and experiments showed the relevance of

predation, and of the availability of light and nutrients, as the main factors controlling Pcy abundance. Addition of phosphate triggers a very rapid response with a fast uptake and transformation of soluble phosphorus to intracellular polyphosphate granules in Pcy and some populations of heterotrophic picoplankton, thus re-establishing the limiting concentration of soluble phosphorus in the lake. This strategy is very significant to explain the dominance of Pcy in this kind of aquatic ecosystems with significant ecological consequences.

30-O   Linking molecular and morphological diversity of unicellular and colonial picocyanobacteria in a hypertrophic shallow lake.

Fernando Unrein [1] - *María Paula Huber* [1] - *Nadia Diovisalvi* [1] - *Marcela Ferraro* [1] - *Sebastián Metz* [1] - *Leonardo Lagomarsino* [1] - *María Eugenia Llames* [1] - *Marta Rollo-Llonch* [2] - *Fernando Bustingorry* [1] - *Roberto Escaray* [1] – *Silvia G. Acinas* [2] - *Josep M. Gasol* [2]

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Single-cell picocyanobacteria (Pcy) are frequently accompanied by colonies of Pcy-like cells embedded within a mucilaginous sheath (CPcy). Some evidences suggested that many Pcy have the capability to aggregate under certain culture conditions. The aim of this study is to disentangle the diversity of coccoids cyanobacteria linking morphological, ecological and molecular information. We performed a polyphasic approach in a hypertrophic shallow lake dominated by coccoids cyanobacteria in order to test the hypothesis that dominant genotypes are present either as single-cell or colonies, whereas their morphological structure (relative abundance of Pcy and CPcy) is mainly driven by zooplankton composition. Autotrophic picoplankton was almost exclusively represented by ficocianine-rich *Synechococcus*-like cells (Pcy). The nanoplanktonic fraction was dominated by colonial coccoids of cyanobacteria (*Aphanocapsa*–like*, Eucapsis* sp. and *Cyanodictyon* sp.), together with microcolonies of Pcy-like cells and short trichomes. Zooplankton assemblage had a strong structuring effect on the composition of these cyanobacteria morphotypes. The small cladoceran *Bosmina* favoured the dominance of CPcy without affecting the total amount of cells. *Cyanodictyon* doubled their colonial size under its presence. Most likely this zooplankter promoted the aggregation of Pcy into CPcy as an anti-grazing strategy. All 16S rDNA sequences retrieved belonged to the "*Cyanobium + Anathece*" clade (Synechococcaceae). Many strains within this family have the capability to aggregate/disaggregate depending on the environmental conditions. Flow cytometry sorting and sequencing of Pcy and CPcy revealed that most sequences recovered were found in both sorted populations, confirming that various Synechococcaceae genotypes can be found *in situ* either as single-cells or colonies.

30-O   Fine-scale spatial changes in microcystis blooms: the critical factor for toxin production?

David Hamilton [1] - *Susie Wood* [2] - *Jonathan Puddick* [2] - *Hugo Borges* [1] - *Dan Dietrich* [3] - *Ian Hawes* [4]

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The existence of prolific blooms of *Microcystis aeruginosa* in shallow (max. depth 4 m), eutrophic Lake Rotorua (Kaikoura, South Island, New Zealand) enabled examination of different aspects of the physiology, anatomy, toxicology and competition dynamics of this species over a study period of five years. We conducted field and experimental studies to examine the factors responsible for changes in cellular microcystin quotas, frequency of toxic genotypes and dominance of *M. aeruginosa.* Microcystin quotas varied up to 100-fold among field samples and were strongly positively related to cell densities. High-throughput sequencing of the intergenic spacer region demonstrated these differences were not due to shifts in the relative abundance of strains. While no single variable was identified as an overarching trigger of microcystin production, large changes in pH and dissolved oxygen at vertical scales of millimetres within blooms suggest that environmental variables may act synergistically alongside possible quorum sensing responses to explain the observed rapid shifts in toxin production. Cryosamplers were developed to complement the fine-scale physical profiles of the bloom and provide a 'snapshot' of the colony anatomy and toxin distribution. They demonstrated high variability of colony size and reinforced relationships of microcystin quotes with cell densities. Conventional monitoring techniques will not capture the high degree of spatial and temporal variability of the bloom and associated toxin production. In this study we demonstrated that new sampling techniques in combination with

molecular tools can enable field studies to improve knowledge of the scale of variability of blooms and toxin production, and are critical to advance our understanding of the triggers of toxin production in cyanobacteria.

30-O Microcolony formation in non-axenic *Synechococcus* cultures: do the associated bacteria matter?

Cristiana Callieri [1] - *Stefano Amalfitano* [2] - *Gianluca Corno* [1] - *Roberto Bertoni* [1] - *Ester Eckert* [1] - *Andrea Di Cesare* [1] - *Nathan Chrismas* [3] - *Patricia Sánchez Baracaldo* [3]

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Cyanobacteria belonging to the genus *Synechococcus* are present in lake waters typically as planktonic single cells and monoclonal microcolonies in association with heterotrophic bacteria. Previous studies have postulated that the formation of *Synechococcus* microcolonies is an efficient defence strategy against grazing activity by size-selective predators. The aim of this study is to evaluate the effect of nanoflagellate predation on microcolony formation in two *Synechococcus* strains belonging to different phylotypes and on their associated heterotrophic community. We designed a factorial experiment with non-axenic *Synechococcus* PE (phycoerythrin-rich cells, Group A, LL) and PC (phycocyanin-rich cells, Group I, MW101C3) as single cultures (PE, PC) and co-cultures (PE+PC) with (+P) and without (-P) the addition of axenic *Poterioochromonas* sp.. During four days of incubation, we followed the dynamics of single-cells, microcolonies and flagellates by flow cytometry, also performing genetic analyses at T_0 and T_4. We observed that the nanoflagellates fed directly on PE cells, and on its associated heterotrophic microbial community, but they were not efficient in removing PC cells. Such prey selection produced a marked decrease of PE single cells and a concomitant increase of PE microcolonies in single (PE+P) and co-cultures (PE+PC+P). On the other hand, PC single cells increased in number, while PC microcolonies were few and did not increase in both treatments (PC+P and PC-P). In PC both the presence of genes involved with predator avoidance like the Exopolymeric Substances (EPS) and the absence of genes involved in cell adhesion (*pil*A) could explain the difference observed in the response of two *Synechococcus* strains to predation. The heterotrophic bacterial community associated to *Synechococcus* was composed of 94 operational taxonomic units (OTUs) dominated by *Gamma-*, *Alpha-*, *Beta-proteobacteria*, and *Flavobacteria* (16S rRNA gene Illumina Miseq sequences). PE and PC cultures differed in the composition of the associated bacteria: in PC Gammaproteobacteria and Flavobacteria dominated while *Sediminibacterium* and *Sphingomonas* were distinctive of PE OTUs. The beta-diversity analysis showed that the communities clustered in two main groups. The one group comprised of the treatments with PC single cultures, with and without predators; the second group comprised of the treatments with PE in single culture and PE+PC co-cultures, with and without predation. 41% of the beta-diversity was explained by the presence of PE, while PC only explained the 9% of the diversity. Moreover, bacterial diversity increased in the presence of predation and in co-culture.

30-O Allelopathic activity of the picocyanobacterium *Synechococcus* sp. on selected cyanobacteria and microalgae.

Sylwia Śliwińska-Wilczewska, Jakub Maculewicz, Adam Latała

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Allelopathy may be one of the key factors contributing to the formation and maintenance of cyanobacterial blooms (Suikkanen et al., 2004), which strongly affected aquatic ecosystems (Stal et al., 2003). Moreover, Allen et al. (2006) described that blooms are occurring in more areas than ever before and new massive blooms are reported regularly. There are some reports of allelopathic effects caused by Baltic cyanobacteria (Suikkanen et al., 2004; 2005), but no information about allelopathic potential of picocyanobacterium *Synechococcus* sp. on coexisting cyanobacteria and microalgae has been found.

The main aim of this work was to estimate the allelopathic interaction of the Baltic picocyanobacterium *Synechococcus* sp. on the coexisting cyanobacteria *Nodularia spumigena* and *Aphanizomenon* sp., green algae *Chlorella vulgaris* and diatom *Skeletonema marinoi*. In this study, the influence of allelopathic activity on the analyzed species was investigated by single and repeated addition of cell-free filtrate of *Synechococcus* sp. Moreover, the influence of allelopathic activity on the growth, chlorophyll fluorescence and photosynthesis performance of analyzed target organisms was investigated.

The present study indicated for the first time that the common Baltic picocyanobacterium *Synechococcus* sp. affect coexisting cyanobacteria, green algae and diatom negatively. The highest decline in growth, fluorescence parameter

F_v/F_m and maximal photosynthesis P_m were observed after the repeated addition of cell-free filtrate obtained from *Synechococcus* sp. On seventh day of experiment, after addition of the cell free-filtrate obtained from the picocyanobacterium, the response of *N. spumigena* was 62% for growth, 45% for F_v/F_m and 35% for P_m. It was examined that the *Synechococcus* sp. reveals allelopathic activity on the photosynthesis and chlorophyll fluorescence which results in the inhibition of growth of analyzed cyanobacterium and microalgae. The observed allelopathic activity can result in distinct ecological advantages to some picocyanobacteria in aquatic ecosystems.

30-O   Toxicity of antibiotics (enrofloxacin and oxytetracycline) on unicells and colonies of the cyanobacterium *Microcystis aeruginosa*.   *Mariana Mendes e Mello* [1] - *Miquel Lürling* [2]

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This study aimed to evaluate the toxicity of two antibiotics commonly used in aquaculture production, enrofloxacin (ENRO) and oxytetracycline (OXYT), on two distinct growth forms of the cyanobacterium *Microcystis aeruginosa*. Hereto, two *M. aeruginosa* strains were grown as unicells and as colonies and exposed to five concentrations of each antibiotic (0, 100, 300, 600 and 1000 µg.L^{-1} ENRO; 0, 1, 2, 4 and 8 mg.L^{-1} OXYT). After 3, 6 and 24 hours of exposure, photosystem II efficiencies were determined. The effective dose (EC50) of ENRO ranged from 103.2 to 132.8 µg.L^{-1} to unicells and from 100.9 to 135.2 µg.L^{-1} to colonies, with no statistical difference between unicells and colonies. The EC50 of OXYT ranged from 0.94 to 0.95 mg.L^{-1} to unicells and from 0.97 to 0.98 mg.L^{-1} to colonies, with colonies showing higher EC50 compared to unicells of the same strain. A second experiment tested the effect of 1 mg.L^1 OXYT on colonies and unicells that had been cultured at a lower concentration of OXYT (0.5 mg.L^1, here considered non-naive) or in its absence (naive). There was no statistical difference of the inhibitory effects of OXYT on naive or non-naive colonies. In contrast, non-naive unicells were significantly less inhibited than naive unicells. Apparently, unicells had a stronger ability to develop antibiotic resistance than colonies. Further studies are necessary to elucidate the dosages when dealing with communities predominately composed by colonies or unicells. Based on other studies and on our results, at environmental realistic doses, ENRO may not affect cyanobacteria, while OXYT can help to control harmful cyanobacterial blooms. Nonetheless, our results suggest that the development of antibiotic resistance should be carefully taken into consideration.

30-O   Possible control strategy of toxic cyanobacterial blooms by algicidal bacteria and growth-inhibiting bacteria associated with reed (*Phragmites australis*) communities in lakes of Ohnuma Quasi-National Park.   *Ichiro Imai, Senri Kojima, Yohei Miyashita, Atsushi Yamaguchi*

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Toxic blooms of cyanobacteria have negative impacts on fresh water ecosystems and water utilization in temperate to tropical areas of the world. Therefore practical and environment-friendly strategies are crucially needed to prevent and control toxic cyanobacterial blooms. Algicidal bacteria that kill noxious species of cyanobacteria are expected to be tools for mitigating impacts of the toxic cyanobacterial blooms and for preventing the occurrences of toxic blooms. This study was carried out to search algicidal bacteria against the toxic cyanobacterium *Microcystis aeruginosa* (strain Ma17) from the biofilm on reeds and water samples in reed communities in Ohnuma Quasi-National Park, and to evaluate for control ability of the cyanobacterial blooms by algicidal bacteria and growth-inhibiting bacteria from reeds.
Bacteria were isolated from the biofilm on reed at four points of Lake Ohnuma and Junsainuma Lake, and water samples from May to October in 2013. The algicidal ability and growth inhibition of the strains of isolated bacteria were examined using *Microcystis aeruginosa* by co-culture experiments.
Algicidal bacteria were detected in high densities (5.2 x 10^5 – 4.8 x 10^6 CFU <colony forming units> g^{-1} wet reed weight) from the biofilm of the surface of submerged reed stems including artificially planted reeds. Algicidal bacteria in water samples were 4.3 x 101 to 2.4 x 103 CFU mL^{-1}. Water samples from reed communities also contained more algicidal bacteria than those water samples from no reed communities. The results suggested a possibility that reeds supply algicidal bacteria to adjacent water of the areas and reed communities have high potential ability to control and/or prevent the occurrences of toxic cyanobacterial blooms via bacteria possessing algicidal and growth-inhibiting activities.

30-P   Summer phytoplankton and different cyanobacterial groups in shallow urban Sava Lake (Serbia) in relation to climatic and chemical parameters.   *Jelena Jovanović* [1] *- Vesna Karadžić* [2] *- Ivana Trbojević* [1] *- Slađana Popović* [3] *- Dragana Predojević* [1] *- Ana Blagojević* [1] *- Gordana Subakov Simić* [1]

Faculty of Biology, University of Belgrade, Belgrade, Serbia [1] *- Institute of Public Health of Serbia "dr Milan Jovanovic Batut", Independent Health Institution of Republic of Serbia, Belgrade, Serbia* [2] *- Institute of Chemistry, Technology and Metallurgy, Department of Ecology and Technoeconomics, University of Belgrade, Belgrade, Serbia* [3]

Summer phytoplankton of some lake is considered to be a very good indicator of its trophic status. With regard to that, in eutrophic reservoirs, summer phytoplankton is mostly dominated by cyanobacteria. Nevertheless, in some periods (with high disturbances), diatoms can prevail. The elements that are most important for phytoplankton development are the macronutrients nitrogen and phosphorus. Majority of the cyanobacteria and eukaryotic algae use mainly nitrogen in the form of nitrate for their growth, while Chroococcales prefer ammonia. In addition, cyanobacteria from the order Chroococcales are also more successful in using phosphorus at low concentrations than some of the larger celled species. Although chemical factors and internal processes influence on phytoplankton succession, external disturbances can also have effect on structure and distribution of phytoplankton. For example, rainfalls or wind induced mixing result in nutrient inputs and can cause the dilution of a portion of the phytoplankton biomass. The effect of these events, such as high flushing rates as a consequence of heavy rainfalls, on development of phytoplankton has mainly been investigated trough laboratory experiments. As these events are not easy to predict, field studies like this are less common. The sampling on recreational reservoir Sava Lake has been conducted weekly from mid of July till mid of September on 3 depths by using Rutner sampler. This water body was created by building of two dams near northern and southern tips of the island Ada, placed on the right side of Sava River on its course through central Belgrade. However, these dams still allow water to flow through pumps and tubes. Quantitative phytoplankton analysis was done by using the Utermöhl method and inverted microscope, while chemical analyses were performed using standard analytical methods. Statistical analysis of our data showed that in July and August cyanobacteria that belong to the order Chroococcales, along with diatoms, were the most abundant in phytoplankton community of Sava Lake. A very high correlation has been observed between these organisms and climatic parameters (precipitation and daily temperature maximum) measured the previous day, as well as transparency. In July, the dominant cyanobacterium was *Aphanocapsa holsatica* (Lemmermann) G.Cronberg & Komárek, while in august *Microcystis aeruginosa* (Kützing) Kützing and few species of genus *Chroococcus* became more abundant. From the end of August and in September, it has been noticed an increase in nutrient concentration and a community succession by chlorococcal green algae and cyanobacteria that belong to the order Nostocales. Thus, redundancy analysis also indicated that nutrients were most likely the cause of this succession.

30-P   Combining epifluorescence microscopy and flow cytometry to quantify and categorize freshwater picoplankton.   *Pauliina Salmi, Anita Mäki, Anu Mikkonen, Marja Tiirola*

Department of Biological and Environmental Science, University of Jyvaskyla, Jyvaskyla, Finland

Microscopy is the traditional and most widely used method to assess picoplankton in limnological studies and monitoring. However, it is often considered inefficient compared to flow cytometry that might count more cells faster and with lower statistical uncertainty. On the other hand, the cytometry data might be difficult to interpret, since it lacks the visual information obtained by microscopy. The purpose of this study was to compare the two methods in assessment of lake picoplankton.
Samples of picoplankton were collected from epilimnia of 45 Finnish lakes in summer 2015. Stained bacterioplankton were scrutinized and unstained picophytoplankton were counted with epifluorescence microscope equipped with blue and green excitation sets. According to their autofluorescence on different excitations, picophytoplankton were divided into phycoerythrin (PE) -rich cyanobacteria, phycocyanin (PC) -rich cyanobacteria and eukaryotic picophytoplankton. The microscopic countings were performed with the aid of real-time statistics so that counting of a sample was completed when the 95% confidence intervals for mean total biomass were < 30%. In parallel with the microscopy, samples were counted with FACSCalibur flow cytometer equipped with blue excitation laser. We hypothesized that the flow cytometer yields similar results to microscopic countings in terms of picophytoplankton abundance, biomass and composition.
According to microscopic results, PC -rich cyanobacteria were the most abundant picophytoplankton group in the study lakes. In the flow cytometry, PC cells showed rather weak autofluorescence on the blue excitation. Instead,

autofluorescence signals of PE cells and eukaryotes were clearly distinguishable. The flow cytometric data analysed so far have shown abundances of bacterioplankton to be one or two orders of magnitude higher than those of picophytoplankton. Flow cytometry and epifluorescence microscopy have produced rather similar picophytoplankton abundances, but the variation in biomass estimates has been notably higher. According to our experience, both the flow cytometry and the epifluorescence microscopy utilizing real-time statistics are current and, at least with this type of a small dataset, equally efficient methods to assess freshwater picoplankton. The most reliable interpretation of the results are likely achieved when these methods are used accordingly in parallel.

30-P   Effect of varying nitrogen and light intensity on the production of extracellular microcystin in monoculture of *Microcystis aeruginosa* and in mixed culture with *Scenedesmus acutus*.   *Pedro Ramírez-García, David Chicalote-Castillo, Víctor Manuel Luna-Pabello*

Universidad Nacional Autónoma de México (UNAM), Mexico City, Mexico

Currently harmful cyanobacteria blooms in eutrophic freshwater systems as lakes and ponds have recurrent high levels of Microcystin-LR (MC-LR), which is a hepatotoxin present in the aquatic medium and seriously affects at different trophic levels. Experimental assays to study the variation of biotic and abiotic factors involved in modifying the response in releasing cyanotoxins allows understand how environmental factors affect this process. Thus, the objective of this study was to evaluate the production of extracellular MC-LR by the cyanobacteria *Microcystis aeruginosa* in monoculture and mixed culture in interaction with *Scenedesmus acutus*, considered as a microalgae sensitive to cyanotoxins. Two experimental treatments were tested by varying light intensity and nitrogen concentration, both were referred as A (90 µmol photons m^2 s^{-1} y 88 N mgL^{-1}) and B (10 µmol photons m^2 s^{-1} y 20 N mgL^{-1}). The results revealed that both treatment A and B did not have significant difference in the production of MC-LR extracellular of *M. aeruginosa* (p> 0.05). In addition, also it is observed that the two treatments did not modify the growth of both cyanobacteria and microalgae of when they grow separately. Also it is observed that the two treatments did not modify the growth of both, cyanobacteria and microalgae when they grow separately. However is greater the growth of S. acutus in the mixed culture under conditions A and B (p <0.05). The results suggesting a null allelopathic activity of the cyanotoxin over the microalgae and also shown that *S. acutus* presence was capable of reducing the concentration of extracellular MC-LR in *M. aeruginosa* (p <0.05). Thus, the results of this study provide knowledge of two abiotic factors and the interaction with other algae species that influence the production of MC-LR by *M. aeruginosa*, which usually participates in harmful algal blooms. This work could be part of a set of approaches and mitigation strategies in order to restore eutrophic aquatic systems.

30-P   *Mcrocystis* modifies biodiversity of planktonic communities.   *Joanna Gadzinowska*

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Microbial ecology is the basic element of functioning in all aquatic ecosystems. The problem of trophic interaction is not recent, since 30 years ago the PEG model explained the role of abiotic and biotic features as significant factors driving the phyto- and zooplankton development in lakes. Nevertheless, an understanding of the interactions between the smallest components of trophic nets in freshwater is a great challenge. Cyanobacteria are one of the main components of the water trophic net, and among many taxa, *Microcystis* is the taxon that is most frequent in eutrophic reservoirs. The common understanding is that zooplankton affects the dynamics and the structure of phytoplankton, but in fact, the opposite relationship also exists. The question is: 'how and does' Microcystis modify diversity of plankton components? Our hypothesis is that zooplankton and Ciliata biodiversity in small reservoirs, which is subjected to Microcystis blooms, are modified, because of the presence of toxins. We sampled small and shallow oxbow lakes of the Vistula River and artificial ponds. All of them are eutrophic and subjected to cyanobacterial blooms (*Microcystis* and other cyanobacterial species). We measured the physico-chemical and biological parameters, and microcystin concentrations in the water. Microcystins were identified as microcystin-LR (MC-LR), microcystin-RR (MC-RR), and microcystin-YR (MC-YR). Samples for biological parameters were collected from the same point and at the same time, and concentrated by plankton nets. Summarizing the results of this presentation, we found that the highest total number of zooplankton species were in the reservoir with long-lasting *Microcystis* blooms. Surprisingly, we found the highest number of cladocerans and copepods, but the lowest number of rotifera in the same reservoir. However, the Shannon index (H) of zooplankton lowered during the phase when microcystins were being released into the water.

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Contrary to zooplankton, we observed that Ciliata showed an increase in the number of species and density during the last phase of the blooms.

We conclude that cladoceran density and species number were lowest during the final phase of cyanobacterial blooms in both oxbows, containing toxins were found. The copepod density and diversity did not show a clear pattern of being dependent on the presence of toxins. However, rotatoria did show a response to toxins in one of the reservoirs but not in the others. These observations support the hypothesis that cladocerans were probably the most sensitive group of plankton animals in the oxbows, and their diversity and density were partly affected by microcystins. Rotifera might respond to microcystins, but they showed a more local than a general response.

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31. GROUNDWATER AND DEPENDENT ECOSYSTEMS (GDES): FROM THEORY TO PRACTICE

31-O   The contribution of groundwater ecology to scientific theories.   *Florian Malard [1] - David Eme [2] - Tristan Lefébure [1] - Florian Mermillod-Blondin [1] - Christophe Douady [1]*

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Groundwater ecology emerged in the second part of the 20th century, although the discovery of organims dates back to the end of the 18th century. As a young research field, it has experienced several paradigm shifts to establish itself as a mature research field of limnology embracing concepts on the evolution, distribution and functional role of biodiversity. Groundwater ecologists are now facing a new challenge which requires « getting out of the groundwater » to solve scientific questions going well beyond the frontiers of groundwater systems. Here, we illustrate how this challenge is being taken up using recent contributions to two big questions facing science: what determines species diversity? Why are some genomes really big and others quite compact? The first contribution capitalizes on the absence of temperature seasonality in groundwater to shed new light on the role of short- and long-term climatic variability in causing a Rapoport effect (i.e. the pattern of increasing species range size at higher latitudes). The second contribution learns from multiple evolutionary groundwater colonization events among aselloid isopods to test for the role of non-adaptive forces (e.g. genetic drift) in driving genome size variation among eukaryotes. Further, we suggest promising research avenues along which groundwater organisms can offer useful case study for addressing major societal issues such as efficient energy use and life span extension.

31-O   Groundwater recharge-discharge dynamics in a changing climate and implications for groundwater dependent ecosystems.   *Mark Cuthbert*

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This paper explores the controls on groundwater recharge-discharge dynamics in a changing climate and the implications for groundwater dependent ecosystems (GWDEs). A catchment can be viewed holistically as a complex system of interacting zones of recharge (i.e. the replenishment of an aquifer) and discharge (the loss of groundwater from an aquifer) mediated by the groundwater flow system, existing in a state of dynamic and often delicate balance, with multiple feedbacks. Groundwater dependent ecosystems (GWDEs) are often located at discharge zones being directly sensitive to climate changes via changes in evapotranspiration, due to altered temperature and CO_2 levels which change rates of groundwater discharge. Changes in recharge (or groundwater abstraction) upstream in the catchment may also indirectly alter the flux of groundwater discharge at GWDEs, but with lag times which depend on the hydraulic diffusivity (D) and length scale (L) of the groundwater flow path via the groundwater response time (GRT=L^2/D). The longest groundwater pathways may be 10s to 100s km sometimes leading to very large values of GRT; thus changes in natural groundwater discharge via transpiration and spring flow or baseflow may therefore lag the forcing climate signal by thousands of years in some cases and be greatly attenuated in magnitude. The long memory of groundwater systems which makes many GWDEs resilient to climatically turbulent periods is evidenced in the geological record, and has recently been hypothesised to have influenced the evolution of our own species. In the present day, understanding the relationship between climate and catchment recharge-discharge dynamics is critical to anticipating and managing the impacts of climate change on GWDEs.

31-O   Groundcare – healthy groundwater ecosystems for healthy drinking water.   *Tobias Siemensmeyer, Cornelia Spengler, Hans Juergen Hahn*

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Groundwater is the second largest freshwater deposit comprising 14 % of all limnic waters on earth and, for many countries, the most important drinking water resource. In Germany, 80 % of the drinking water is of subterranean origin. A functioning, healthy ecosystem is essential for high quality drinking water, also minimizing the costs of processing exfiltrated water. In order to assess groundwater ecosystem services and the effects of impacts, the joint project GroundCare has been launched in summer 2015.

GroundCare is a BMBF (German Federal Ministry of Education and Research) funded multidisciplinary project which is led by the Helmholtz Institute in Munich, Germany. The aim is to parametrize and to quantify groundwater ecosystem services as a basis for sustainable water management and water pollution control by biomonitoring. Several parameters will be evaluated ranging from physico-chemical parameters via microbial and faunal community composition through to eco-toxicological effects on invertebrate organisms. Seven sites, located all across Germany, reflect different kinds of lands use and groundwater systems. In combination, a protocol using standardized sampling methods and ecological/biological concepts shall be implemented for groundwater assessment and evaluation of its ecosystem services.

The fauna-part of GroundCare will be processed by the Institute for Groundwater Ecology (IGÖ GmbH, Landau, Germany). The central idea is to combine und compare morphologic and genetic community data. Along ecological gradients, changes of the communities will analyzed using both classical taxonomy and molecular techniques like barcoding and metabarcoding. Especially since further developments of NGS (Next Generation Sequencing) techniques, metabarcoding might be a fast and more accurate way to identify species and to assess communities in groundwater ecosystems, thus providing a promising tool for future biomonitoring.

31-O   The hydrogeological point of view on GDES: the concept of Groundwater Associated Aquatic Ecosystems (GWAAE) and case studies from Central Italy.   *Marco Petitta* [1] *- Mariachiara Caschetto* [1] *- Klaus Hinsby* [2] *- Johan Schutten* [3] *- Matt Craig* [4] *- Hana Prchalova* [5]

Dipartimento Scienze della Terra, Sapienza University, Rome, Italy [1] *- Geus, Copenaghen, Denmark* [2] *- Scottish Environmental Protection Agency, Sepa, Glasgow, United Kingdom* [3] *- Irish Environmental Protection Agency, Dublin, Ireland* [4] *- Water Research Institute, Prague, Czech Republic* [5]

Water bodies, including rivers, standing waters, transitional and coastal waters where the surface water ecology and hydrology is dependent on contributions from groundwater have been classified as Groundwater Associated Aquatic Ecosystems (GWAAE, EC, 2015). In detail, an ecosystem contained in surface water bodies could be affected by alteration of groundwater level or pollutant concentration that are transmitted through groundwater, leading to possible changes of its status or its environmental objectives as stated in the WFD.

Groundwater contributes flow to the majority of surface water bodies, to a varying degree depending on the hydrogeology and physical setting. The groundwater component of the flow may fluctuate significantly throughout the year, affecting the influence of the groundwater input to the ecological or chemical status of the surface waters. The groundwater importance to a GDE is connected with the supply from groundwater flow, even though in some cases relatively small groundwater contributions may be ecologically significant, with particular reference to periods of low flow.

Different categories of GWAAE can be identified, based on the level of groundwater dependency: when the ecology of a surface body is critically dependent upon groundwater, it can change its ecological or chemical status due to a deterioration in quantity of quality of groundwater input; in other cases, surface bodies are able to withstand substantial changes in groundwater inputs with no changes in status.

The groundwater needs of GWAAE have not been systematically defined, other than general assessments of base-flow groundwater requirements. Characterization and risk-assessment include: initial characterization (when links with GWAAE and related pressures from surface and groundwater bodies are identified), further characterization (when dependency of the ecosystem to groundwater quality and quantity is evaluated) and risk assessment (based on a receptor approach and/or on a groundwater approach as starting points). Monitoring activities of groundwater bodies, coupled with a specific monitoring on the GWAAE where it is at risk or is being damaged, require a conceptual understanding of the interaction between groundwater, surface water bodies and the dependent ecosystem, to be evaluated in cooperation with ecologists.

Specific situations and needs of individual GWAAE will vary because of local conditions, such as hydrological variations, due to natural or human induced causes, and a common framework is required to assist consistent assessment and decision making in the GDE field, e.g. when assessing groundwater quantitative and chemical according to WFD and GWD. This goal requires a closer interaction between scientific disciplines in developing conceptual understandings

including GWAAE identification, characterization and monitoring. Some examples from Central Italy are provided as reference points.

31-O   Surface water - groundwater interactions: effect on nutrient transport over watersheds.
Fulvio Boano

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Many studies over the last years have highlighted how surface water and groundwater represent interconnected environments whose physicochemical features are strongly influenced by their interconnections. For instance, water exchange at the interface between rivers and aquifers plays an important role on nutrient cycling because of the biogeochemical reactions that occur in hyporheic sediments and influences nutrient export through the river network. Physicochemical alterations of rivers and their surroundings induced by anthropic activities impact the interactions between surface waters and groundwater and can thus negatively affect riverine ecosystems. However, it is still difficult to quantify the impact on these ecosystems of surface-subsurface water exchange and of its alterations because of our limited understanding of the underlying physical and biological processes and also because of the intrinsic heterogeneity of river and aquifer properties.

This contribution stems from the need for predictive tools of water and nutrient exchange between surface water and groundwater and describes some lessons obtained from modeling studies of surface-subsurface exchange at different spatial scales. Water exchange flows at small (e.g., meter) scales are predicted to provide the largest contribute to nutrient reactions. These small-scale flow processes are mainly driven by local stream morphology, but they are also strongly influenced by groundwater flow at larger (e.g., kilometer) scales. A conceptual framework to describe the interactions between surface water and groundwater over a wide range of spatial scales is discussed.

31-O   The assessment of quality standards in eu groundwater dependent ecosystems: the case of ionized ammonia (NH₄⁺).
NH_4^+).   *Tiziana Di Lorenzo* [1] - *Diana M.P. Galassi* [2] - *Marco Cifoni* [2] - *Maria Elena Sáenz* [3] - *Walter Dario Di Marzio* [3]

Institute of Ecosystem Study , ISE CNR, Firenze, Italy [1] *- Department of Life, Health and Environmental Sciences, University of l'Aquila, l'Aquila, Italy* [2] *- Programa de Investigación en Ecotoxicología, Departamento de Ciencias Básicas, Universidad Nacional de Luján, Conicet, Luján, Argentina* [3]

Groundwater contamination represents a threat to groundwater dependent ecosystems (GDEs) with acute and chronic effects on aquatic organisms, as well as on human health. EU legislation provides for measures against chemical pollution of freshwaters, through either setting EQSs (European Quality Standards) for single substances of EU-wide concern (priority substances, such as pesticides) or delegating the Member States (MS) to set the QSs for substances of national or local concern (such as NH_4^+). According to the Annex V of the Water Framework Directive (WFD 2000/60/EC), a good chemical status is reached for a water body when it complies with the EU and national QSs. However, there are several concerns about the approach indicated in the EU technical guidance document (TGD) to derive QSs for GDEs, with particular reference to ecotoxicological data. According to Annex V of the WFD, the base set of taxa that should be used in ecotoxicological trials to set QSs are algae and/or macrophytes, the cladoceran crustacean *Daphnia* and epigean fish. However, none of these taxa naturally dwell in groundwater bodies nor are dominant or even occur in some GDEs. Although the TGD underlines that the ecotoxicological trials should not be restricted to this base set, the actual QSs for EU groundwater bodies have been generated from experiments on epigean species, so far.

The objectives of our studies were: (i) to test the acute and chronic effects of two compounds widely used in EU farming, namely NH_4^+ and the herbicide Imazamox, as well as of their binary mixture, to an epigean and a hypogean copepod species belonging to the same family; (ii) to derive the QSs for NH_4^+ computed respectively as single chemical and in the binary mixture with Imazamox by species sensitivity distributions (SSDs) based on a set of freshwater species including groundwater copepods. We selected the Crustacea Copepoda since it is by far the most abundant and species-rich group in groundwater and GDEs.

The results of our studies warned about using epigean species to derive QSs for GDEs. In our studies, the two copepod species showed a differential sensitivity to NH_4^+ when assayed as single chemical. In details, the hypogean species was 3 and 37 times more sensitive than the epigean species under acute and chronic exposure to NH_4^+, respectively. However, the difference in the sensitivity between the two species was far less evident when NH_4^+ was assayed in the

mixture. The QS of NH_4^+ obtained by the SSD curve computed for the single compound highly underestimated the fraction of the potentially affected species, that were more sensitive to NH_4^+ when it was considered in the mixture with Imazamox in the SSDs. According to the QS of NH_4^+ derived from our studies, the actual environmental policy fails to protect groundwater copepods from acute exposure to NH_4^+ in at least 4 EU Member States.

31-O   Interactions between geochemical and ecological status of the groundwater ecosystem: what do the resident biological communities tell us?   *Annamaria Zoppini [1] - Stefano Amalfitano [1] - Tiziana Di Lorenzo [2] - Daniele Parrone [1] - David Rossi [1] - Stefano Ghergo [1] - Elisabetta Preziosi [1]*

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The groundwater ecosystems are threatened by the increasing water demand and anthropic activities. Groundwater hosts numerous organisms belonging to a wide range of faunal groups that generally are neglected by the monitoring plans, commonly based on the hydrogeochemical parameters. Basic research is needed to establish the effects of the environmental stress on the whole system.

The groundwater ecosystems are populated by highly adapted biota, dominated by microorganisms and invertebrates. Microbial communities are at the base of the heterotrophic food chain, playing a key role in the organic matter processing, including organic pollutants. Important ecosystem services are attributed to groundwater metazoa, especially invertebrates, such as the maintenance of hydraulic conductivity in porous sediments, through their feeding on microbial biofilms, and bioturbation. The analyses of the microbial and crustaceans communities in the groundwater along with changes in hydrogeochemical parameters may contribute to shed more light upon the state and dynamics of such ecosystems. A comprehensive study of a water table aquifer flowing through a quaternary volcanic district (Latium Region, central Italy) was performed. Field data (GPS localization, well depth, water table level, temperature, pH, alkalinity, dissolved oxygen, conductivity) were measured together with the analysis of major cations (Optical Emission Spectroscopy), major anions (Ionic Cromatography), trace elements (Coupled Plasma Mass Spectrometry), NO_2, PO_4, NH_4 (Spectrophotometry) and dissolved organic carbon (Shimadzu TOC-5000 analyzer). The Colilert-18 test was used to verify the occurrence of fecal contamination (total coliforms and *Escherichia coli*). Flow cytometry and epifluorescence microscopy was utilised to determine the prokaryotic abundance and cells with high and low nucleic acid content (HNA, LNA). BIOLOG EcoPlates™ were utilised to describe changes in the metabolic profiles of the microbial communities. Pore water ($1m^3$) was filtered through a 63-μm mesh net to sample crustaceans specimens, successively sorted under a stereomicroscope for taxonomic identification.

The sampled sites were differently affected by natural and anthropogenic factors (arsenic, fluoride and fecal pollution). The analysis of the results showed as differences in the aquifer typologies affect the structure and functional properties of the bacterial communities(range 10^3-10^4 cells/ml). The microbial communities metabolic profiles (BIOLOG) were surprisingly different among the sites for all the classes of substrata analyzed (amines/amides, amino acids, carboxylic acids, carbohydrates, polymers), implying a high metabolic diversity. The crustacean community was constituted by 12 taxa, nine of which were stygobionts. Interestingly four sampling sites, belonging to the same sector of the aquifer, with a lower salinity and sulfate content, harbored no crustacean specimens.

31-O   Groundwater biodiversity in the challenging sulfidic karst: copepod assemblages of the Frasassi cave system (Italy).   *Diana M.P. Galassi [1] - Barbara Fiasca [1] - Alessandro Montanari [2] - Alessia Di Cioccio [1] - Tiziana Di Lorenzo [3] - Simone Fattorini [1]*

Department of Life, Health and Environmental Sciences, University of L'Aquila, L'Aquila, Italy [1] - Osservatorio Geologico di Coldigioco, Apiro (Macerata), Italy [2] - Institute of Ecosystem Study, ISE CNR, Firenze, Italy [3]

The Frasassi cave system hosts one of the few worldwide examples of groundwater metazoan communities depending on chemoautotrophic microbes. Despite the challenging conditions represented by high levels of hydrogen sulphide and low concentration of oxygen, this cave system is home to many species of ostracods, amphipods, and copepods. We analysed here the copepods inhabiting three sulfidic lakes and two dripping pools fed by non-sulfidic water to investigate how the extreme environmental conditions of sulfidic habitats influence community structure. To this end, we have sampled copepod assemblages in both low- and high-water periods characterised by different physico-chemical conditions. Overall similarity in species composition among species assemblages was investigated by cluster analysis

(Sørensen coefficient + UPGMA) whereas relationships between species composition and environmental parameters were analysed by canonical correspondence analysis (CCA). To investigate if copepod community structure was influenced by sulfidic conditions, we compared diversity, dominance and equitability values of sulfidic lakes during low- and high-water periods. Cluster analysis and CCA separated the dripping pools (whose species assemblages were associated to higher pH and oxygen concentrations) from sulfidic lakes (whose species composition was strongly affected by ionic concentration). These results indicate that the distribution of stygobiotic copepods within the cave system is ecologically and spatially structured. For example, the planktonic *Eudiaptomus intermedius* and *Diacyclops cosanus*, and the inbenthic/interstitial *Eucyclops intermedius* and *Nitocrella stammeri*, are able to cope with the high ionic content and hypoxia of the sulfidic lakes, even if they avoid sulfidic microbial mats below the chemocline. Contrary to expectation, sulfidic lakes showed lower dominance, higher diversity and higher evenness in the higher sulfidic state. This paradoxical situation was due to the fact that extreme conditions reduced the abundance of dominant planktonic species, thus making the community structure more balanced. Species assemblages of dripping pools were very different from those found in the sulfidic lakes and included both stygobiotic and non-stygobiotic species. Differences in relative species abundances between pools suggest that the epikarst fracture network has interconnected but different drainage pathways. The relatively high biodiversity and complex community structure of the copepods inhabiting the Frasassi cave system indicate that a chemosynthetically produced food source allowed ancestral populations of surface-water crustaceans to settle permanently in sulfidic groundwater, probably due to their preadaptation to tolerate harsh environmental conditions.

31-O   StygoTracing-EZG - applying population genetical methods on hydrogeological catchment assessment.   *Susanne van den Berg-Stein, Hans Juergen Hahn*

Institute for Groundwater Ecology Igö Gmbh & Working Group Molecular Ecology, University of Koblenz- andau, Landau, Germany

A central challenge both for quality assurance of water supply and for wetland management is the description of hydrological connectivity and water fluxes in the catchment area.

For that purpose a molecular biological method was developed – StygoTracing. StygoTracing is based on population genetics and identifies hydrological fluxes using animals as biological tracers. The technique has yet been applied for water lice both in drinking water supply systems and in the outdoors catchment.

The application for the hydrogeological investigation in the field using different tracer species is in its very beginning. It shall be optimized for practise by StygoTracing-EZG. EZG stands for the „Einzugsgebiet" (German for catchment). StygoTracing-EZG is an applied research project focussed on the stygophilous and stygobitic fauna in the catchment. The project aimes to use these animals as biotracers for hydrogeological connectivities.

In this presentation the conception of the project and the perspectives of the new technique are presented.

31-O   Groundwater flooding: responses of groundwater ecosystems to an extreme recharge event.
Anne Robertson [1] *- Katarina Fussmann* [1] *- Stefan Krause* [2] *- Julia Reiss* [1]

Department of Life Sciences, Roehampton University, London, United Kingdom [1] *- Geography, Earth And Environmental Sciences, Birmingham University, Birmingham, United Kingdom* [2]

The winter of 2013-2014 was the wettest in the UK since records began resulting in extremely high groundwater levels and very extensive groundwater recharge, particularly in chalk aquifers. Understanding of the impact of such conditions on the unique ecosystems that exist in groundwaters is very limited yet such extreme events are predicted to become more frequent under climate change.

We hypothesised 1 that the composition of the groundwater community will change following flooding cessation and the onset of community recovery. 2 Dissolved Organic Carbon (DOC) will be highest immediately after flooding, the microbial compartment will respond rapidly to high DOC levels and groundwater macrofauna will recover more slowly. We collected environmental data (e.g. DOC, nutrients, oxygen profiles) and measured microbial functional diversity, fungal activity, and the abundance and biomass of bacteria, protozoa, meiofauna and macrofauna. We did this at multiple boreholes in each of two chalk aquifers across a 7 month period following the recharge event.

We found that DOC and bacterial abundance were higher shortly after the recharge event and then declined whereas protist biomass and macrofaunal abundance increased with increasing distance from the recharge event. However,

even in the early months of the study macrofaunal abundance was higher than that found in a study a few years earlier. Although macrofaunal abundance increased over time, biomass was lower because juvenile stygobites were more numerous, possibly as a result of reproduction. We used body mass-abundance plots to demonstrate that communities in both aquifers exhibited a strong size structure.

Our study presents the first data on the responses of groundwater communities to flooding and provides a baseline against which future extreme events in groundwaters can be measured. It will enable us to compare the responses of groundwater ecosystems to stressors with those of other aquatic ecosystems.

31-O   Using surface-subterranean transition events to test for the effect of ultraviolet and natural radioactivity on the rate of molecular evolution.   *Nathanaëlle Saclier* [1] *- Tristan Lefébure* [1] *- Florian Malard* [1] *- Patrick Chardon* [2] *- Clémentine François* [1] *- Lara Konecny* [1] *- Christophe Douady* [1]

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Identifying the intrinsic and extrinsic factors that cause variation in the rate of molecular evolution among species can have profound implications for understanding mechanisms driving large-scale biodiversity patterns, diversification rate and species coexistence. Here, we used closely related species of surface and groundwater asellids (Pancrustacea, Isopoda) to test for the effect of ultraviolet (UV) and natural radioactivity on the rate of molecular evolution. For each species, we sequenced the transcriptome and estimated the rate of molecular evolution using a total of 386 orthologous genes present across all species of asellids retained in this study. For ultraviolet solar radiations, we used 13 independent surface-subterranean species pairs and tested whether the rate of molecular evolution was significantly higher among surface water species. As transition to groundwater includes modifications in life history traits which can also decrease the evolution rate, we also searched for an excess of specific UV signature mutations among the surface species, defined as the preponderance of CC to TT substitutions at dipyrimidine sites. For radioactivity, our comparative approach was based upon four pairs of subterranean species, the members of which colonized habitats with contrasted levels of natural radioactivity. In the absence, yet, of any specific signature mutations for radioactivity, we tested for a positive relationship between the rate of substitution and natural level of radioactivity in groundwater habitats, while considering potential confounding factors. We found that the rate of molecular evolution was significantly higher among surface water species than groundwater species. However, this pattern was apparently caused by factors other than UV (e.g. life-history traits) because we found no evidence for a higher proportion of CC to TT substitutions among surface water species. Among groundwater species, the substitution rate increased significantly with increasing natural radioactivity level, even after accounting for phylogenetic relationships among species. Although this finding awaits corroboration using more species, it outlines, for the first time, a potential effect of low natural levels of radioactivity on the rate of molecular evolution at time scales of millions of years.

31-O   Linking science and private business – a perspective for groundwater ecology?   *Hans Juergen Hahn*

Institute For Groundwater Ecology Igö Gmbh & Working Group Molecular Ecology, University of Koblenz Landau, Landau, Germany

In the public perception, science is focused on maximal cognition, while private business aims to make money. Science, in particular ecology, is far away from real life, aiming to get the very best results without regarding costs, efforts and applicability. In contrast, private companies try to get results with a minimal effort and a maximum of efficiency. Both approaches are thus often considered to be highly oppositional. I feel that this is just pure theory, and that there often exists a smooth transition between science and business.

Groundwater ecology is still a "developing science" compared to other limnological disciplines. Even basic information on groundwater ecosystem functioning and species distribution are lacking. In very most countries there is no legal background for groundwater ecology, and no standards for assessment are yet available. Not amazing, that ecological groundwater research is not in the focus of public promotion and funding.

This unsatisfactory situation may also be a chance, since there is definitely a demand for consulting and consultants with groundwater ecological background. Such work for water authorities and public water supply creates a lot of basic data, which can be used for research and publishing, too. Further-more, there is a big benefit for university and

education, since many bachelor, master and phD students can be involved in those projects. Last, but not least, such a public private partnership creates personal and intellectual continuity – probably the main profit for all partners.
In this presentation I'ld like to share our experiences of five years of groundwater ecological work in close association between university and privat consultancy.

31-O   Towards a new typology and quality scoring of UK groundwater habitats.   *Damiano Weitowitz [1] - Louise Maurice [2] - Melinda Lewis [2] - Anne Robertson [1]*

CRE, University of Roehampton, London, United Kingdom, [1] - British Geological Survey, Wallingford, United Kingdom [2]

Although groundwater studies are in their infancy, the factors governing the distribution of subterranean ecosystems are known to mainly relate to geology and the provision of nutrients and oxygen in a heterogenous environment. A satisfactory answer to the question whether geology controls the distribution of groundwater ecosystems is mainly hindered by the broad habitat typologies used in analyses (e.g. karstic, porous, fractured). Many researchers have also called for the incorporation of quantitative hydrogeological and hydrochemical data into habitat frameworks. The primary aim of this paper was to determine a higher resolution typology of geological habitats (geo-habitats) based on lithological and hydrogeological information. To do so, ArcGIS 10.1 was used to group all geological units in England and Wales (1:50k scale) into 11 'geo-habitats'. The study then wanted to determine the hydrogeological (e.g. transmissivity) and hydrochemical (e.g. DO, DOC, Ca, NO3) characteristics of each of these habitats, using data from previously published studies. Furthermore, a quantitative method to assess overall groundwater habitat quality is introduced. The lithological grouping method resulted in 11 distinct geo-habitats, which had significantly different hydrogeological and –chemical conditions. Overall, karstic and porous geo-habitats are characterised by higher concentrations of nutrients, while DO was highest in fractured geo-habitats. Interestingly, all geo-habitats have patches with high and low quality, which may have important implications for ecosystems. Taking into account subterranean heterogeneity, the habitat quality scores indicate that the highest species abundance and diversity can be expected in karstic and porous geo-habitats, whereas fractured habitats should be characterised by depauperate ecosystems. Extensive areas of England and Wales are covered by low-quality fractured habitats, increasing the relative importance of high-quality habitats for groundwater biodiversity. The distribution patterns show that karstic geo-habitats are organised in north-south trending, connected belts, which most likely facilitates faunal dispersal. Using a more detailed framework enables researchers to better analyse the extent of geological control on groundwater ecosystems and species habitat preferences. As a next step the current framework should be set into context of faunal distributions to test its explanatory power.

31-O   Trapped in the web of water: springs are island-like ecosystems for the stygobiotic meiofauna.

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Groundwater-fed springs may be considered as island-like systems for obligate aquatic invertebrates that have low capability to cross the surrounding terrestrial landscape and to successfully disperse across the surface hydrological network with little thermal or hydrological buffering. However, springs can be interconnected by contiguous aquifers which may allow dispersal via groundwater pathways. In this research we analysed the copepod meiofauna of 30 springs in the Central Apennines (Italy) to investigate the impact of geographical proximity in determining variations in species richness, overall inter-spring meiofaunal similarity (measured using the Sørensen index, ßsor), pure turnover (measured by Simpson index, ßsim), inter-site nestedness (ßnest = ßsor-ßsim) and matrix nestedness (measured using NODF, spectral radius, temperature and discrepancy). As possible correlates of species richness we considered spring area, discharge and elevation. We conducted separate analyses for the total number of species, and for stygobiotic (obligate groundwater dwellers), non-stygobiotic, cold stenotherm and non-cold-stenotherm species separately. A multimodel selection procedure based on AIC values was applied to select best fit models using both ordinary least squares regressions and autoregressive models that took into account the spatial component (spring latitude and longitude). In general, explicit consideration of spatial correlations reduced the importance of predictors of overall species richness, non-cold stenotherm species (both negatively affected by elevation), cold-stenotherm species, and non-stygobiotic species, but increased the importance of area for the stygobiotic species. We detected significant nested patterns in all

cases, except for the stygobites. Inter-spring distances were positively correlated (Mantel tests) with ßsor and ßnest (but not with ßsim) for the entire data set and for non-stygobiotic, cold-stenotherm and non-cold stenotherm species. In the case of stygobites, inter-spring geographical distances were marginally correlated with ßsor and no correlation was found for ßsim and ßnest. These results suggest that stygobites have a low capability to move even through the aquifers and tend to be mainly confined to the springs where they drifted out and trapped by spring-bed sediments.

31-O   Punctual but not minor – contribution of high alpine spring dwelling diatom and nematode communities to biodiversity in glacierized catchments.   _Ursula Eisendle-Flöckner_ [1] _- Maurizio Battegazzore_ [2] _- Sylke Hilberg_ [3]

Department Cell Biology, University of Salzburg, Salzburg, Austria [1] _-, Chiusa di Pesio, Italy_ [2] _- Department Geography and Geology, University of Salzburg, Salzburg, Austria_ [3]

Springs represent important groundwater dependent habitats for freshwater organisms that in turn exert important functions for these systems. Springs are often described as relatively restricted in both space and variability of flow and hydrochemical conditions. But different landscapes and climatic conditions can form highly different spring types, which might be subdivided into highly distinct substrate patches. In this context it seems so that alpine springs above tree line are less well known than their lowland counterparts particularly with regard to their inhabitants of various substrates. In addition, for springs in general, some spring dwellers are better known (i.e. algae, crustaceans, insects and mollusks) than others. Among the latter are for example free-living nematodes that are considered to be of importance to freshwater habitats.

In this regard, we investigated high alpine springs (1880 - 2450 m a.s.l.) in the Eastern alps (Austria) for their diatom and nematode communities. Springs were situated within an area of the penninic Tauern Window consisting mainly of carbonmica-schists of the so called „Schieferhülle". The aquifers can be characterized as low permeable fractured and only slightly karstified. Groundwater flow is bound to foliation, layer boundaries or small karst conduits. Thus, springs are comparably small and scattered. Mean residence times of the spring water within the aquifers are supposed to reach at least several months or even some years.

15 springs were characterised by basic abiotic parameters (water temperature, conductivity, oxygen content, pH). Epiphytic (partly lacking at some springs; diatoms, nematodes), epilithic (diatoms) and benthic (nematodes) communities are described in terms of α-diversity per spring and per habitat, ß-diversity as descriptor of species turn over between and among respective sites and habitats, and diatom/nematode specific indices (e.g. trophy, feeding type, maturity).

With 167 taxa, diatom overall species richness was distinctly higher than that of nematodes. In general, abundant diatom taxa were _Achnanthidium minutissimum_, _Diatoma mesodon_, _Achnanthidium pyrenaicum_ and _Diatoma hyemalis_. Diatom and nematode richness ranged from 20 (epilithic) to 40 (epiphytic) and from 6 (benthic) to 25 (epiphytic) species, respectively. In particular diatom indices were all coherent with the near-pristine, oligotrophic characteristic of these high altitude Alpine sites. Diatom species richness and Trophic Index were slightly higher for epiphytic than epilithic biota. For nematodes no clear preponderance of high species number for either epilithic or epiphytic substrates between respective sites has been observed.

The partly considerable differences that emerged between springs and habitats are discussed with respect to their additive biodiversity value for high alpine, glacially influenced catchments (γ - diversity).

31-O   Groundwater warming and threshold values - which temperatures can groundwater invertebrates stand?   _Cornelia Spengler_, _Hans Juergen Hahn_

Institute For Groundwater Ecology Igö Gmbh & Working Group Molecular Ecology, University of Koblenz- Landau, Landau, Germany

Temperature is one of the most important factors in ecosystems and has a strong influence on metabolism and behavior of organisms. Unlike epigean aquatic habitats, groundwater ecosystems are characterized by constant temperatures. Reflecting the annual mean of the air temperature, groundwater temperatures in Central Europe are thus generally low and vary between 10 and 12 °C. During the last two millions of years, annual mean temperatures didn't exceed 14 °C. The general expectation is that stygofauna has adapted to these conditions. Groundwater invertebrates are therefore considered to be cold-stenothermous with a critical temperature of 14 °C.

Expecting a global warming of 2 °C within this century, the annual mean of air temperature will reach or even exceed this 14 °C-limit, in Central Europe. Locally, groundwater is used for industrial or private cooling purposes, leading to underground temperatures up to 20 °C and more.

The question is what this will mean to stygofauna. Field studies on temperature preferences of single species are yet not available and the few studies from the lab support the assumption of a cold-stenothermous stygofauna.

To find out the temperature optima of typical groundwater species, we analyzed all available data on groundwater fauna across Germany. Additionally we conducted threshold change point analysis (using TITAN software) to identify the critical temperatures for these species. Against our expectation, some definitely stygobiontic species tolerate or even prefer warm temperatures. However, most groundwater species seems to prefer cold temperatures below 14°C. Increase of groundwater temperature due to anthropogenic usage of groundwater and due to the predicted global warming are thus very likely to affect groundwater communities substancially.

In this presentation, we will consider the effects of groundwater warming from an autecological perspective and present temperature optima and threshold values of typical stygofauna species.

31-O   The importance of choosing the scale in groundwater fauna study.   _Oana Teodora Moldovan_

Emil Racovitza Institute of Speleology, Romanian Academy, Cluj Napoca, Romania

Sampling frequency and spatial distribution of selected sampling points are crucial for understanding diversity and fauna dynamics in groundwater habitats. We tested these assumptions in two different settings by adding he measured physico-chemical parameters in the analysis. Different spatial and temporal scales were applied for hypogean fauna from the hyporheic zone on a polluted stretch of the Aries River and the dripping water in Ciur-Izbuc Cave, both in NW Romania. Monthly versus seasonal (hyporheic zone and cave) or daily (cave) samplings were tested in different stations along the river and the cave, respectively. Sampling of the hyporheic zone and the dripping water showed contrasting biodiversity and abundance patterns at different time scales. Sampling dripping points along the cave gave contrasting results in communities' composition and abundances with implication in understanding connectivity and metacommunity distribution in a largely heterogeneous environment such as the unsaturated karst zone. Correlations with water physico-chemical parameters for seasonal series were sometimes contradictory and appeared to be artifacts related to sparse data for the hyporheic zone. The results show that monthly or more frequent sampling together with increasing density of sampling points and in different parts of one river or one cave are required for a complete assessment of biodiversity and fauna dynamics in the groundwater habitats and for studying the relationship with surface ecosystems.

31-O   Diversity and functionality of groundwater viral communities.   _Li Deng [1] - Michael Seidel [2] - Rene Kallies [3] - Christian Drosten [4] - Christian Griebler [1]_

Institute of Groundwater Ecology, Helmholtz Zentrum München, Neuherberg, Germany [1] - Chair of Analytical Chemistry & Institute of Hydrochemistry, Technical University Munich, Munich, Germany [2] - Department of Microbiology, Helmholtz Center for Environmental Research, Leipzig, Germany [3] - Institute of Virology, University Hospital Bonn, Bonn, Germany [4]

Viruses are the most abundant and diverse biological entities on the planet and their impact is global. They affect microbial hosts through mortality, re-mineralization of nutrients, and horizontal gene transfer. Phages can even drive the evolutionary trajectory of the Earth's fundamental biogeochemical processes by encoding "host" genes that are expressed during infection and confer a direct fitness advantage for the phage.

While viral communities in surface freshwaters and marine systems received considerable attention in the recent past, our knowledge about viruses, others than pathogens, in groundwaters is almost zero. Sampling pristine as well as organically contaminated groundwater from different sites in Germany, we aim to shed light into the viral diversity and functionality.

Viral particles were concentrated from large amounts of groundwater (tens of cubicmeters) via nanofiltration. Viral communities were then investigated by means of viral tagging, metagenomic pyrosequencing, and protein cluster (PC) analysis. We build a PC datasets using viral metagenomes from freshwater and groundwater habitats, in conjunction with the marine viral GOS and POV data set to minimize the bias when analyzing the groundwater viral metagenoms.

Viruses in groundwater were dominated by dsDNA bacteriophages of the families of Myoviridae, Podoviridae and Siphoviridae. The dominance of tailed-morphology Myoviridae in our groundwater sample was confirmed by

Transmission Electron Microscopy (TEM). Comparison of the groundwater viral metagenomes with different metagenomes from a variety of other aquatic environments (marine and freshwater) revealed that the freshwater viral consortia were more close to each other than to marine consortia. However, no significant difference between freshwater (including groundwater) and marine viral assemblies could be found, which is likely due to the insufficient sample size of the current database. The cluster richness of each virome, deduced from PCs, was significantly different between the groundwater environments from others, with the highest diversity being observed in groundwater. Mapping metabolic pathways from viral metagenome data obtained from groundwater of an organically polluted site revealed that viruses in this system carry bacterial functional genes related to biodegradation of the site-specific contaminants. Current research is directed to the functional role of viral communities in groundwater ecosystems.

31-O   Sub-fossil subterranean habitats in the centre of Sahara – rich source of stygobites.   _Brancelj Anton_

National Institute of Biology, University of Nova Gorica, Ljubljana, Slovenia

The Sahara is among the driest part of the World, where normally less than 50 mm of precipitation is delivered per year. In the central part of Sahara there are several high-level plateaus (usually 1500-2000 m above sea level) which are a mixture of ancient volcano's craters, lava fields and silica-sandstone formations, surrounded in low-land by sand-fields (in Arabic: _ergs_). On the slopes of these plateaus a network of deep and narrow valleys (wadis) formed by ancient rivers is present. Some of the wadies are up to 200 m deep and up to 1 km wide, with steep or vertical slopes.
Along these wadies, particularly in the lower parts, where they come into contact with the ergs, there are a series of small permanent freshwater bodies (lakelets; usually between 5 and 50 m across) known locally as "gueltas – qalta – galta – agelmam". They are source of water for traditional nomadic people (Tuaregs) or local inhabitants.
In most of the gueltas abundant freshwater zooplankton and phytoplankton co-occurs; in some of them also macrophytes, benthos and fish. Presence of fish is a proof that those water bodies never dry-out in the past. They exist there since more than 6000 years ago and represent remnants of network of ancient rivers. The gueltas are filled mainly by adjacent ground water which originated from those ancient rivers. Small part of water enters nowadays the gueltas and aquifers occasionally by rain, too.
There are about 90 groundwater species known from the Sahara, collected in the caves, wells and interstitial habitats along the rivers. Many locations were sampled on northern or southern rim of the Sahara and only few in the central part.
During two expeditions (2007, 2014) a biological survey was carried out in groundwater habitats of the wadis of Mouydir Plateau (Algeria) and Tibesti Plateau (Tchad). In two shallow wells (1.5 m deep; KC type) groundwater was sampled and a rich fauna of new stygobites was discovered, being Copepoda (5 taxa), Isopoda (1 taxon) and Syncarida (2 taxa) the dominant taxa. This result is a preliminary indication that shallow aquifers in the wadis represent unknown but interesting habitats for groundwater fauna in unconsolidated sediments as well as source of water for adjacent surface water bodies.

31-O   Effects of submarine groundwater discharge on coastal ecosystem and fishery production.   _Makoto Taniguchi_

Research Institute for Humanity and Nature, Research Unit, Kyoto, Japan

Submarine groundwater discharge (SGD) is recognized as one of the water and dissolved materials pathways from land to the ocean. In this study, the interaction between SGD and coastal ecosystem/fishery production was analyzed and evaluated in Obama City, Fukui Prefecture, Japan. The objective of this study is to evaluate the effects of groundwater used as heat energy for the melting of snow accumulated on roads, on the ecosystem and fishery production in the coastal area. The SGD, which carries nutrients into the coastal ocean, is reduced by excess groundwater pumping used for melting snow on land. Positive correlation has been found between primary production rates in Obama Bay and radon concentrations which show the magnitude of the SGD. Therefore, the increase in groundwater pumping on land reduces nutrient loads to the ocean and affects the coastal ecosystem, including the reduction of fishery production. Results of 3D numerical simulations of the basin scale groundwater model show a reduction of SGD by 5 percent due to an increase in groundwater pumping by 1.5 times. This reduction of SGD caused a 3.7 ton decrease in fishery production.

The groundwater-energy-fishery nexus was found in Obama Bay, Japan and the tradeoff between water and food was evaluated.

31-O   Chase the direct impact of rainfall into groundwater in Mt. Fuji by multiple analyses including microbial DNA.   *Ayumi Sugiyama [1] - Suguru Masuda [1] - Kazuyo Nagaosa [1] - Takanori Nakano [2] - Maki Tsujimura [3] - Kenji Kato [1]*

Graduate School of Science, Shizuoka University, Shizuoka, Japan [1] - Research Institute for Humans and Nature, -, Kyoto, Japan [2] - Faculty of Life and Environmental Sciences, University of Tsukuba, Tsukuba, Japan [3]

A huge amount of groundwater is stored in subsurface environment of Mt. Fuji, the largest volcanic mountain in Japan. Based on the concept of piston flow transport of groundwater residence time of the groundwater stored in Mt. Fuji was estimated to ca. 15-30 years by $^{36}Cl/Cl$ ratio (Tosaki et al., 2011). This number, however represents an averaged value of the residence time of groundwater which had been mixed before it flushes out. In order to elucidate the route of groundwater in a given system we chased signatures of direct impact of rainfall into groundwater, employing microbial analysis in addition to stable isotopic analysis (delta ^{18}O) and chemical analysis (concentration of silica). Though chemical analysis of groundwater shows an averaged value of the examined water which was already blended by various water run from different sources through different routes in subsurface environment, microbial analysis could suggest the place where they originated and passed.

Throughout the *in situ* observation of four rainfall events showed that stable oxygen isotopic signature of spring water and shallow groundwater obtained from 726m a.s.l. (G1) where the average recharged height of rainfall was in between 1500 and 1800 m became higher than the values observed before a torrential rainfall exceeding 300 mm in precipitation, and the concentration of silica decreased after this event. In addition, the density of Bacteria in spring water apparently increased, which suggested and/or influence of heavy rainfall. Those changes did not appear when rainfall did not exceed 100 mm per event. Thus, findings shown above indicated a fast flow of rainfall which run shallow part of aquifer and appeared within a few weeks of torrential rainfall in the studied geological setting. In addition, we excitingly found that in the density of Archaea increased in the deep groundwater at G3 being ca. 12km downstream from G1 after the torrential rainfall, though chemical parameters did not show any change after the event. This may suggest a possibility that strengthen piston flow caused by torrential rainfall brought Archaeal particles from the geological layer in the route of groundwater. The finding was supported by changes in constituents of Archaea through predominating with *Halobacteriales* and *Methanobacteriales*, which were not retrieved from other observation. Those two groups of Archaea were thought to be relatively tightly embedded in geological layer and were extracted from the environment to the examined groundwater by enforced piston flow. Microbial DNA thus can give information about the route of groundwater, which was never elucidated by analysis of chemical materials dissolved in groundwater.

31-O   Anaerobiosis in alluvial sediments in karst caves suppress microbial metabolic activities.   *Janez Mulec [1] - Andreea Oarga-Mulec [2]*

Karst Research Institute, Research Centre of The Slovenian Academy of Sciences and Arts, Postojna, Slovenia [1] - University of Nova Gorica, University of Nova Gorica, Nova Gorica, Slovenia [2]

Sinking rivers deposit in karst caves sediments, which contain beside inorganic material also organic matter and microorganisms. Alluvial sediments along 9.5 km of underground water flow of the Pivka River in Postojna Cave System (total length 24.1 km), Slovenia, containing >10^5 Colony-Forming Units of microorganisms per gram of dry weight, were sampled to ascertain community-level physiological profiling. Metabolic fingerprinting revealed moderate impact of temperature (10°C, 20°C and 30°C) during aerobic cultivation on microbial utilization of 31 different substrates (Ecoplates, Biolog). Microbial ability to degrade substrates significantly dropped during anaerobiosis, for example the following substrates were not metabolized in any of the eight samples at all three temperatures: α-Cyclodextrin, 2-Hydroxy Benzoic Acid, 4-Hydroxy Benzoic Acid, γ-Hydroxybutyric Acid, α-Ketobutyric Acid, L-Phenylalanine, Phenylethyl-amine. Microbial capability to metabolize all tested substrates during aerobic cultivation was not completely retrieved when these samples were afterwards cultivated aerobically, particularly α-Ketobutyric Acid, 2-Hydroxy Benzoic Acid and α-Cyclodextrin. Interestingly, microbes from an old alluvial sediment sample, which age was estimated between 20,000 and 780,000 years exhibited no metabolic activity during anaerobiosis, but switch to aerobiosis largely recuperated

microbial activity. Oxygen level and to a certain extent also temperature affects ecology of cave sediments which contain metabolically diverse microbes.

31-O   Groundwater microbiological contamination in Sinai.   *Aziza Kamel*

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Groundwater plays an essential role in global drinking water supply. In Egypt, Fresh groundwater resources contribute to 20% of the total water resources potential. Egypt is an arid country, having a large hydro geologic potential, with many groundwater aquifers widely distributed throughout the country. Sinai Peninsula has two major sources of water: 1 the renewable flash or rough water from floods and 2 the non-renewable groundwater of the Nubian Aquifer. Weathering is an important natural phenomena controlling contamination of groundwater aquifers. Mineral retention of bacteria in groundwater aquifers has a significant impact on water quality. To date, a large range of bacterial strains or communities from diverse genera have been reported to be able to colonize mineral surfaces. Saprolite, bedrock weathered upper surface, harbors wide members of the division Proteobacteria including pathogenic bacteria such as, bacteria causing gastroenteritis (Escherichia coli, Salmonella, Shigella, Vibrio), other Enterobacteriaceae, soil pathogenic bacteria (Pseudomonas, Acinetobacter), as well as non-parasitic symbiotic nitrogen fixing bacteria. Poorly constructed sewage treatment plants and land uses of sewage wastewater can lead to groundwater contamination close to water supply sources. At St. Katherine city, South Sinai, groundwater is heavily contaminated by untreated domestic wastewater from sewage. In several studies conducted here, fecal indicators (E.coli, fecal streptococci), as well as, other bacterial pathogens including Salmonella, Shigella and Vibrio species were detected in all monitored wells. Virus persistence in aquifers environment is affected by attachment to the weathered crystalline rock surfaces under favourable conditions, i.e. pH and ionic strength (IS) conditions. Subsequently, virus detachments due to perturbation in IS and pH, may lead to several outbreaks. Outbreaks due to enteric hepatitis and gastroenteritis causing viruses have been attributed to groundwater contamination from septic tanks. The present study aims to develop and apply a mathematical model to predict virus fate and transport at selected groundwater sites of Sinai, Egypt. It aims also to determine the impact of domestic wastewater percolation on groundwater pollution in Sinai.
Water samples are collected from selected regions of Sinai. Physical, chemical and microbiological characteristics including: fecal indicators (E.coli, enterococci), total coliforms and viruses are studied. The study will establish appropriate setback distances for pumping wells used for domestic and drinking purposes in Sinai. The modeled setback distances will be assessed by experimental measurements in order to ensure safe drinking water supplies from wells. This study will evaluate the minimum requirements for water treatment, in order to ensure a safe drinking water.

31-O   Analyzing the dependence of coastal lagoons on groundwater: the case of Pletera lagoons (NE, Spain)   *Anna Menció[1], Josep Mas-Pla[2], Laura Rovira[1], Cristina Burgos[1], Xavier D. Quintana[3]*

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In Mediterranean areas, coastal lagoons and wetlands have been the focus of an increasing interest due to the loss and degradation of their ecological status, in terms of declining biodiversity, an alteration of their ecological functioning, and a limitation of their ecosystem services. In this context, the Horizon 2020 Programme of the European Union has set, as one of its priorities, to prevent a further degradation of these ecosystems and to recover their ecological functioning.
The Pletera salt marsh area (NE Spain), is located in the north of the mouth of the Ter River, in a region mainly predominated by agriculture and tourism activities. In this area there are some coastal lagoons and wetlands that have been affected by an incomplete construction of an urban development. These wetlands and lagoons are the focus of a Life[+] project, whose aim is to restore this protected area, and to recover its ecological functionality. The Pletera coastal lagoons are periodically flooded by both, freshwater from streams and seawater, during storm events. However, this surface water inputs are insufficient to maintain these lagoons, and the importance of groundwater in their natural dynamics is still unknown.
Consequently, the aim of this study is to analyze the hydrogeological dynamics in the Pletera coastal lagoons (NE, Spain) as a basis to propose guidelines for their sustainable management. In order to determine the importance of

groundwater in these lagoons, monthly hydrochemical (with major ions, nutrients and tracers) and isotopic ($\delta^{18}O_{H2O}$ and δD) campaigns have been conducted, from November 2014 to October 2015. In particular, groundwater from six wells, surface water from nearby streams and permanent lagoons, and seawater were considered in these surveys. The Pletera lagoons show similar hydrochemical characteristics to seawater, with Na^+-Cl^- facies and high EC values, even exceeding seawater EC during dry periods (ranging from 38 to >100 mS/cm). In these periods, lagoons are affected by evaporation processes, showing $\delta^{18}O$ and δD values higher than +5 and +10 ‰, respectively. In addition, results of a preliminary hydrochemical model show that during humid periods freshwater from the aquifer may suppose the 80% of the lagoons water, while during dry periods, this influence do not seem so clear (with a maximum of 50%), mainly due to evaporation processes. Considering that groundwater in this area, may present lower N concentrations than surface inputs observed during flooding events, these results reinforce the importance of groundwater dynamics in these systems, not only to maintain the permanent lagoons during dry period.

31-P Interstitial meiofauna in an alpine headwater stream (South Tyrol, Italy). *Roberta Bottarin[1], Ulrike Tappeiner [1,2]*

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Headwater streams may be small in size, but they provide habitats for a rich array of species, which provides an enhancement of the biological diversity of the entire lotic system. These water courses are very sensible to climate changes, even minor changes of the environmental conditions can have significant consequences on these biological communities. The numerous small alpine valleys, which often are not investigated at all from the zoological point of view, thus represent ideal sampling sites for studying sensible organisms. Moreover, in mountain valleys, beyond individuals with a broad distribution area, also endemic organisms characterized by a very restricted distribution range are living.
This study was designed to determine for the first time the faunal composition of the hyporheos within the Saldura stream, a perennial glacial alpine water course, focusing on temporal and spatial effects of the melting process of snow and ice on the composition of the interstitial meiofauna communities. The Saldura catchment, due to its particularity dry conditions, is ecologically very relevant and belongs to the alpine LTER sites. The presence of a glacier within the drainage basin influences the hydrology of the whole water course as well as all environmental conditions. These changes may be have fundamental implications on the river biota. In order to evaluate the glacier's influence and the longitudinal patterns of meiofaunal assemblage 4 sampling stations have been selected (located between 2300 m a.s.l. and 1500 m a.s.l.). The meiobenthic community has been sampled at 30 cm depth within the riverbed applying the Bou-Rouch-method. The monthly samples of meiofauna have been integrated by chemico-physical analysis of the interstitial water in order to correlate community composition, diversity and environmental variables. The results have shown longitudinal as well as seasonal distribution patterns: the increasing discharge due to the snowmelt during June and July corresponds to a decrease of total faunal density and number of taxa. Beside the typical hyporheic faunal assemblages (Copepods, Nematoda, Tardigrada, Collembola, Cladocera) a very rare Archianellida has been discovered for the first time in South Tyrol and has been find just in few other sites all over the world. The unexpected finding of *Troglochaetus beranecki* Delachaux, 1921 in all four sampling sites along the perennial glacier stream provides a further contribution to the knowledge of the diffusion of this Archianellida in inland European waters. Actually, not much is known about the ecology of this particular stygobyont all over the world.

31-P Quantification of major ions in groundwater using analytical techniques and statistical approaches. *Bretcan Petre [1] - Tanislav Danut [1] - Radulescu Cristiana [2] - Pohoata Alin [2] - Stihi Claudia [2] - Dulama Ioana Daniela [3] - Stirbescu Raluca Maria [3]*

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Groundwater is used for domestic consumption including drinking water as well as for irrigation. It is well known that the water-related health problems are the result of microbial and chemical contamination of drinking water. The main objective of this study was to determine quantitatively the contributions of various groundwater nitrate pollution

sources including chemical fertilizers and animal wastes applied to croplands using the statistical approaches of PCA. In this respect, over 100 groundwater samples were collected from pre-existing wells, situated mainly in rural agricultural area from Romania, between September and November 2014. Sampling was performed in according with EPA Guide for Ground-Water Sampling. Dissolved cations including Ca, Mg, Cr, Fe, and Mn, were analysed using an iCAP™ Q ICP-MS. Dissolved anions (i.e. SO42-, NO3- and Cl-) were determined using ion chromatography. Alkalinity of groundwater samples was measured by titration method to quantify the carbonate species (mainly HCO3-). Quality control (QC) of chemical analyses was achieved by analyzing blanks duplicate samples as well as by calculating charge-balance error (CBE). A statistical analysis of quantitative source apportionment for the chemical investigated elements was performed. The chemical parameters were interpreted with Principal Component Analysis (PCA). Pearson correlation coefficient matrix using a Student's t distribution in MatLab is used to determine the linear dependence between the analysed parameters. Schoeller diagram achieved with the RockWare AqQA program is presented for analysed ions (SO42-, HCO3-, Cl-, Ca2+, Mg2+) behaviour interpretation.

31-P   Development of a full-life cycle and reproduction bioassay with the freshwater cyclopoid Eucyclops serrulatus.   Marco Cifoni [1] - Diana M.P. Galassi [1] - Cecilia Faraloni [2] - Barbara Fiasca [1] - Tiziana Di Lorenzo [2]

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Groundwater dependent ecosystems (GDEs) worldwide are endangered by frequent and intense, large-scale disturbances due to chemical stressors. Toxicity tests are essential tools for biomonitoring and risk evaluation of chemical substances released in these environments.

Due to their dominance in aquatic environments, crustacean species (especially the Copepoda, that is the most abundant meiofaunal group in GDEs) are emphasized as target taxa in acute and chronic ecotoxicological bioassays. However, the attention on copepods in ecotoxicology had concerned almost exclusively marine or brackish species up to now. Only few ecotoxicological full life-cycle bioassays with freshwater copepods are available due to laboratory handling. Aside the requirement of experience and technical proficiency in handling these small-sized organisms, problems arise in selecting the most appropriate diet and temperature that assure at least 70% of survival in the control (test acceptability criteria) and minimize the developmental rates. Moreover, much relevance must be addressed to set up the conditions that maximize the fertility and reproduction of the target species.

This study was aimed at developing a full-life cycle (egg to adult to egg) and reproduction bioassay with the freshwater cyclopoid Eucyclops serrulatus. To this end, the effect of four different diets (two microalgae species: Chlorella sorokiniana, Scenedesmus dimorphus; a mix of the two algae and a prokaryotic diet) on the development and reproduction of E. serrulatus was investigated in two different culturing cells namely, glass vials (2 mL) and 96-polystyrene microwell plates (0.2 mL), at two diverse temperatures (18° and 25°C). Culturing cell water renewal and feeding were done every 3 days. We selected E. serrulatus since it is one of the most abundant epigean cyclopoids in GDEs and fulfils the requirements to be a good indicator such as a wide geographic distribution, resistance to manipulation, simple maintenance in the laboratory, short development, short life-span and high fecundity.

Survival (%) and developmental endpoints (days) were assessed monitoring the growth of newly hatched nauplii (1152), aged 24 hours, individually. Reproduction endpoints were assessed as: number of clutches, number of eggs, number of hatched nauplii/clutch. Estimations of population growth rates (λ) were modelled by a Lefkovich matrix. Survival, developmental and reproduction endpoints, as well as λs, were compared across treatments using permutational analyses of variance (PERMANOVA). Post hoc t-tests were applied when appropriate.

The results of this study showed that the bioassay performed with the algal mix diet, in 2-mL glass vials and at 25°C, assures the highest survival rates (88%), the shortest developmental rate (25 days), the maximum lifetime reproductive success and the highest population growth rate.

31-P   Earthquake-related changes in species niche overlaps in a karstic springwater copepod community.   Barbara Fiasca [1] - Alessia Di Cioccio [1] - Tiziana Di Lorenzo [2] - Silvano Porfirio [1] - Diana M.P. Galassi [1] - Simone Fattorini [1]

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We analysed niche overlap (Pianka's α index based on species abundance across sites) in the subsurface copepod community sampled in the springs of the River Tirino (Central Italy) at the boundary of the Gran Sasso aquifer (central Italy) in low-discharge (1997), high-discharge (2005), and post-seismic, very high-discharge (2012) hydrological years. The aquifer was hit by a 6.3-Mw earthquake in April 2009. To assess if the year-specific mean niche overlap values differed from those expected by chance, we compared the observed values with the expected means obtained from simulated null-assemblages using the RA3 and RA2 algorithms. We considered both pairwise overlap (α) and species mean overlap (α_{sp}, calculated as the average of the pairwise α values of all couples in which a certain species was involved), analysed with repeated measures ANOVAs. For the analysis of pairwise α values, we grouped species pairs into three types: 1 pairs in which both species were stygobites, 2 pairs in which one species was a stygobite, and 3 pairs in which both species were not stygobites. We divided species into stygobites and non-stygobites also for the analysis of α_{sp}. Deviations of niche overlap values from null expectations suggest that the stygobiotic community in 1997 was influenced by interspecific interactions. Results for 2005 were inconclusive, because the two algorithms produced contrasting results, but results for post-seismic 2012 clearly indicated an unusually large mean niche overlap, especially for non-stygobiotic species, which is suggestive of strong interspecific interactions. Thus, environmental changes responsible for the increase of mean species niche overlaps affected stygobites and non-stygobites in a similar way. However, when species pairs were analysed, we found significant differences also between 1997 and 2005. These results suggest that differences in mean aquifer discharge may generate strong temporal fluctuations in species abundance at the spring outlets, with changes in the niche overlap between species pairs (α) even when the mean interaction of a species with the others taken together (α_{sp}) remains similar. This is what happened between 1997 and 2005, but the 2012 scenario was different, because mean species niche overlaps increased significantly in 2012. This suggests that this increase cannot be due to natural changes in species abundances driven by differences in aquifer discharge, but could be associated with the exceptional high-discharge of the Gran Sasso karstic aquifer triggered by the 2009 earthquake. An analysis of co-occurrences revealed that increases in niche overlap were paralleled by a reduction in species segregation. Our investigation suggests that the increase in niche overlap may be related to an increase in interspecific interactions in turn determined by changes in species fine-scale distribution among subsurface spring microhabitats

31-P Preliminary data on microbiological and biotic monitoring in Romanian show caves. *Ruxandra Nastase-Bucur [1] - Silviu Bercea [1] - Marius Kenesz [1] - Oana Teodora Moldovan [1]*

"Emil Racovitza" Institute of Speleology, Romanian Academy, Cluj Napoca, Romania [1]

The present study is part of an ongoing project, CAVEMONITOR, including five Romanian show caves; the main idea is that no protocols were yet compiled for monitoring cave fauna for longer periods of time (two years). Aquatic invertebrates were collected from percolating water, while terrestrial invertebrates were monitored in situ. Also, a novelty element is that we have taken in consideration the microbial monitoring both of the pools water and cave air, correlated with a series of abiotic features of the caves, such as temperature, air relative humidity, number of particles in the air. Two of the investigated caves, Ursilor Cave and Muierilor Cave, were studied on a monthly basis, other two caves, Meziad Cave and Polovragi Cave, once in two months and, finally, one cave, Fundata Cave, on a semestrial basis. For fauna we installed 1-2 stations/cave. Cave air microbiological monitoring consisted in a various number of stations along the touristic path, but also 1-2 stations in the non-touristic part of the caves. Pools water was microbiologically monitored in 1-2 stations in each cave. We used RIDA@COUNT plates exposed either to cave air or water as a very easy method and counted the number of microorganisms for five days at 24h interval. Five types of mediums were used: total counts of bacteria, Yeast&Molds, *E.coli*/Coliforms and Enteriobacteracaea. We will present the preliminary results of the first year of biological and microbiological monitoring, with indications on seasonal variation in fauna abundance, as well as differences in microbial counts between stations of the same cave and between the five caves.

31-P Groundwater fauna and how to teach in biology lessons. *Julia Domberger [1] - Sylke Hilberg [2] - Ursula Eisendle-Flöckner [3]*

Biology/geology, University of Salzburg, Salzburg, Austria [1] - Geology and Geographics, University of Salzburg, Salzburg, Austria [2] - Biology, University of Salzburg, Salzburg, Austria [3]

Groundwater is stored in subsurface voids within sediments and hard rocks. It is transport media for dissolved solids, particles and heat. What is widely unknown for most people is that groundwater bodies are also ecological systems and provide habitats for a wide range of organisms, ranging from vertebrates to the microbiota. Integrating this kind of knowledge means a distinct change of point of view for teachers in biology since their usual interests are surface related organisms. So far, groundwater - and in particular the subsurface fauna - seems to gain not that interest that it would deserve in teaching processes – maybe, because it´s not visible. But is it essential for teachers to consider groundwater and it´s fauna in biological lessons? Yes, it is! Basically, teachers have the possibility to enlarge the consciousness of young people for the environment and the world they live in. Although the existence of faunal life in groundwater is widely unknown by most persons, groundwater animals are an important part of this environment and provide crucial ecosystem services. The aim of this study is to create a working package for teaching groundwater fauna in biology lessons – based on the results of an empirical study within a porous groundwater body in Salzburg (Austria).

Hydrogeology and the principles of groundwater flow are common knowledge in geoscience. However, in biology classroom lessons many misconceptions are taught because of teacher´s own knowledge gap concerning subsurface flow and much more concerning subsurface life. These misconceptions can be cleared by.. 1 explaining some basic principles and facts about hydrogeology and 2 introducing groundwater bodies as habitats for complex communities. Therefore an empirical study on groundwater inhabitants in a porous aquifer in the Salzach valley was conducted. Groundwater fauna samples were taken at three observation wells and the inhabitants were determined on different levels (higher taxa up to species level). Aside fixed material different visualisation methods such as raster electron microscope and light microscope pictures were used to present crustaceans, nematodes and oligochaetes as teaching material. One focus was to show different size classes in relation to the habitable pore space as well as the different function of different types of organisms. The material is arranged for a compact teaching unit comprising both frontal lecture and self-learning phases.

31-P   The EC-AQUALIFE project in Italy: filling the gap between water quality assessment and biodiversity monitoring in GDES.

Alessia Di Cioccio [1] - *Barbara Fiasca* [1] - *Silvano Porfirio* [1] - *Monica Di Francesco* [2] - *Andrea Piermarocchi* [3] - *Simone Fattorini* [1] - *Diana M.P. Galassi* [1]

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The groundwater dependent ecosystems (GDEs) are facing many threats due to anthropogenic disturbance. Despite their widely recognized relevance (Directive 60/2000/EC and Directive 118/2006), the GDEs are still not object of specific regulation and their ecosystem dimension is never considered in monitoring issues. The only exception is that of the so-called groundwater associated aquatic ecosystems (GWAAEs), i.e. ecosystems belonging to surface water bodies (rivers, lakes, transitional WB or coastal WB), whose ecological or chemical status can be affected by alterations of groundwater level or pollutants transported through groundwater. Blurred perception and cognition of the groundwater persist in EU regulations: groundwater may serve to sustain surface ecosystems. This is true, but not enough: just looking at the tip of the iceberg in that it is visible and easy to identify and know, regardless the huge portion beneath the surface.

The main objective of the AQUALIFE project is to enter routine biomonitoring programs in groundwater by developing the AQUALIFE package, a user-friendly software package for the assessment of biodiversity status and trends in the GDEs.

The study area involved in the AQUALIFE project is the Abruzzo region (central Italy), where 550 sampling sites were selected from three main GDE types: 1 entirely, 2 highly, and 3 opportunistically dependent on groundwater. These sampling sites were selected to reflect impact gradients on the basis of the location of the main pressures known at the regional scale, according to the classification given in the Water Information System for Europe (WISE), and the water physicochemistry per site.

We have found that both surface-water insect larvae and the meiofauna were sensitive to high concentration of ammonium detected at several sites in the hyporheic zone of the Sagittario River, the Tirino River and the Gamberale stream. Our preliminary analyses indicated a significant reduction of species abundance in sites polluted by ammonium ($N-NH_4^+ > 0.0653$ mg L^{-1}, the minimum threshold value fixed by most EU countries for groundwater). These results confirmed the relevance of ammonium as contaminant of emerging concern. Coastal aquifers, as in the Vomano River catchment, were affected by marine intrusion, spot presence of chlorinated organic compounds, and ammonium. At these sites (boreholes), stygobiotic abundances decreased, and euryhaline species dominated the communities in groundwater sites where marine intrusion was detected.

31-P Incorporating invertebrate conservation concern in prioritization of groundwater habitats.

Silvano Porfirio [1] *- Simone Fattorini* [1] *- Barbara Fiasca* [1] *- Alessia Di Cioccio* [1] *- Tiziana Di Lorenzo* [2] *- Diana M.P. Galassi* [1]

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Selection of priority areas in conservation biology should incorporate an evaluation of the conservation concern of the species that compose different assemblages. In the groundwater dependent ecosystems (GDEs), stygobiotic, strictly GDE-dependent, microhabitat specialised, endemic species are more important – from a conservation point of view – than non-stygobiotic, opportunistic, habitat generalist and widely distributed taxa. To evaluate the conservation importance of GDE assemblages, we used the Crustacea Copepoda as surrogates of the total invertebrate fauna, and developed a conservation priority index based on the degree of stygobization, GDE-dependency, microhabitat specialization and endemicity of the species that compose an assemblage. To calculate this index, each species was scored for each of these traits and then received an overall conservation value score that was the sum of the various trait scores. Species scores were finally combined to prioritize sites according to their species assemblages.
To cope with practical difficulties in identifying groundwater invertebrates to species level, we have also developed a second, similar index that expressed conservation priorities on the basis of degree of stygobization, dependence on GDEs and microhabitat specialization at supra-specific level. Focusing on these traits established at supra-specific level, and not requiring the taxonomic identification to the species level, means that even non-specialists can use this index. For this, we considered not only the Copepoda, but also Mollusca, Ostracoda, Isopoda, Amphipoda and Syncarida. Supra-specific level varied among taxa, from species-group to superorder according to ease of identification. Due to the use of supraspecific taxa, we did not consider here endemicity. We tested the two indices both karstic and alluvial aquifers in the Lessini Massif (northern Italy). The aquifers were analysed by sampling boreholes in order to allow comparison among sites sampled with the same procedure, thus avoiding the sampling bias related to differences in sampling devices. We found that the two indices tend to be correlated, which suggests that the second one may be used for practical purposes when identification to species is difficult due to the lack of taxonomic expertise. The same approach has also been applied to the smaller aquifer of the River Vomano (central Italy), and the results obtained were similar, suggesting the informative potential of the indices at different spatial scales.

31-P Isotopic assessment of groundwater patterns in an aquifer of the Poopo Basin, Bolivia. *Etzar Gomez - Gerhard Barmen - Jan-Erik Rosberg*

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In the Bolivian highlands, groundwater has become the most important and safe source of water for consumption when rivers and lakes have been reduced due to the effects of climate change. However, thermal saline intrusions and mining activities have reduced the quality of the water in the region. During the Quaternary the Central Bolivian Altiplano was the site of several transgressions and regressions of paleolakes reported throughout that period. The last lake in the region is called Poopo and is the most important discharge zone in the enclosed catchment, although it was declared dried up in 2015 by the Bolivian State due to intense evaporation. The material deposited by the fluvial-lacustrine activity are composed of coarse to fine grain sediments in which the most productive porous aquifers are contained. Decades of exploitation of these groundwater reservoirs, combined with the limited information required to understand the circulation patterns, represent a challenge for the groundwater management. In this study, isotopic compositions of deuterium and 18-oxygen in different stages in the hydrologic cycle are analysed to assess flow patterns in an aquifer supplying Oruro, the biggest city in the region. The most extensive data records of stable isotopes, tritium, radiocarbon and electrical conductivity, have been collected in the alluvial fan of Paria River where a well-field has been exploiting the aquifer in the last fifty years. This study estimates about 80 % of the annual precipitation over the region falls during the summer, from December to March. It is comprised of the most depleted stable isotopic values. This fingerprint is similar to the majority of the groundwater samples collected in wells. The linear tendency of the groundwater isotopic compositions below the Global Meteorological Water Line exposes the effect of evaporation in shallow and intermediate circulation systems. Modern precipitation is the most important recharge source until about 100 m below

surface. Conversely, deeper levels seem to be recharged by different processes, possibly at higher altitudes or ancient times.

32. EFFECTS OF MULTIPLE STRESSORS IN A CHANGING WORLD

32-O   Exposure to a heat wave under food limitation makes an agricultural insecticide lethal.   *Robby Stoks* [1] *- Lizanne Janssens* [1] *- Khuong Dinh Van* [2]

University of Leuven, Leuven, Belgium [1] *-Nha Trang University, Nha Trang, Viet Nam* [2]

Synergistic combinations of anthropogenic stressors are of major concern for biodiversity loss. While extreme temperatures and exposure to agricultural pesticides are becoming more frequent and intense under global change, their joint effects have been poorly studied. The potential for delayed interactions, and their modulation by the often co-occurring food limitation, may be especially problematic, yet have been ignored. We tested for the effects of a transient heat wave combined with food limitation, and subsequent exposure to a widespread agricultural pesticide (chlorpyrifos) in *Coenagrion puella* damselfly larvae. The direct effects of the heat wave included a 3% increase in mortality and reductions in immune function (measured as activity of phenoloxidase, PO) and in metabolic rate (measured as activity of the electron transport system, ETS), which were not magnified by starvation. Starvation had both direct and delayed negative effects on growth rate, Hsp70 levels, total fat content, and activity levels of PO and ETS. Exposure to chlorpyrifos negatively affected all response variables, yet for mortality and immune function this was only in larvae previously exposed to the transient heat wave and starvation. This delayed synergism was especially striking for mortality: while the heat wave caused only minor mortality and starvation had no direct effect on mortality, chlorpyrifos caused considerable (48%) mortality, yet only in larvae that were previously exposed to both the heat wave and starvation. This could be partly explained by the inhibition of acetylcholinesterase (AChE) and the cumulative metabolic depression caused by each of these stressors. Furthermore, the delayed negative effects of the transient heat wave and starvation, combined with the direct negative effect of chlorpyrifos, considerably (71%) reduced larval growth rate. The here identified delayed synergism provides a novel explanation for the poorly understood potential of heat waves and of sublethal pesticide concentrations to cause mass mortality.

32-O   Snapshots and movie making – different paradigms in freshwater science.   *Peeter Nõges*

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While reviewing papers which quantified effects of multiple stresses on aquatic systems, we discovered big differences between the approaches used in river and lake studies referring to the existence of slightly different paradigms in these fields of science. The saying by Heraclitus that no man ever steps in the same river twice, for it is not the same river and he is not the same man, seems to have strongly influenced the paradigm of river research. Science always tries to see beyond the appearance. To study rivers which are dynamic systems, one needs a snapshot to see the details – like in sports photography. The striking difference in the time window for data collection in river compared to lakes categories revealed by our meta-analysis, clearly reflects the fact that the bulk of river data is collected using single surveys. An obvious reason for that is the water body concept for rivers described as a continuum or sequence of individual sections. Because a river changes constantly as it moves downstream, a large number of river sections need to be studied to detect disturbances. Due to rotation of river stations in many monitoring schemes, no time-series for the same sites are built up. To compensate for the missing time dimension, a large variety of functional attributes of taxa have been developed showing the feeding type, reproduction biology, preferences for biocoenotical region, habitat, and flow velocity.
To study lakes which are more static by appearance, intuitively one needs a time series (like a movie) to see the dynamics. The bulk of lake data in the analysed papers represented time-series of different length. The distinct boundaries of lakes where all inputs and outputs of matter and energy can be easily measured, has made lakes the favourite model systems for studying whole ecosystem processes. Leading theories in lake research study the dynamics of fundamental processes. Owing to the available long time-series on lakes extendable to thousands of years by palaeo-studies of lake sediments, lakes have been recently recognised as sentinels and integrators for the effects of climate change on watersheds, airsheds, and landscapes. Although process parameters reflecting nutrient dynamics, community metabolism, or food web processes were significantly more often described in lakes compared to rivers, still the majority of 'dynamic' metrics was constituted by time series of simple structure metrics such as concentrations,

biomasses and abundances. It is difficult to say whether the burden to carry on the time-series once started has hindered lake researchers to develop functional structure metrics for lake communities, or there have been other reasons for that, however, as our analysis showed, these metrics were less developed for lakes.

A wider use of time-series in river studies and development of functional metrics for lake communities could be the way how the two paradigms could mutually enrich each other.

32-O   The effects of nitrogen and terrestrial dissolved organic carbon on trophic transfer efficiency to zooplankton.   *Carolyn Faithfull, Anne Deininger, Ann-Kristin Bergström*

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Trophic transfer efficiency is a measure of the efficiency of energy transfer from basal trophic levels such as phytoplankton and bacteria up to zooplankton. It has been argued that trophic transfer efficiency is lower in lakes with high inflows of terrestrial dissolved organic carbon (T-DOC). In high T-DOC lakes, high bacterial production relative to phytoplankton production can result in an increased number of intermediate trophic levels between bacteria and zooplankton, which results in multiple levels of respiratory carbon loss before the basal carbon reaches zooplankton. Consequently, high T-DOC lakes should have lower trophic transfer efficiency (TTE = Zooplankton production / phytoplankton + bacterioplankton production) than lakes with lower T-DOC inputs. Many high T-DOC lakes are found in the boreal zone, where atmospheric nitrogen inputs are low, but the latter will potentially increase in the future due to forestry fertilization. In this study we examine the interacting effects of T-DOC concentration and nitrogen addition in a large scale whole lake experiment. Six lakes were paired based on their catchment characteristics and T-DOC concentrations. To three of these lakes nitrate was added for two years, and the other three lakes served as controls. Measurements of bacterial production, phytoplankton production and zooplankton biomass were taken during a reference year before nitrogen addition and during the two years with nitrogen addition, over the ice-free season from May to September. Zooplankton production was measured every two weeks in fish free in situ mesocosms and from rates of population changes in each lake. Whole lake energy mobilization was calculated as bacterioplankton production based on terrestrial organic carbon + phytoplankton production. We hypothesise that basal energy will be partitioned differently between bacterioplankton and phytoplankton production depending on T-DOC concentration; total basal production will consist of a higher percentage of bacterioplankton production in the high T-DOC lakes. We tested if this difference in partitioning has a significant effect on zooplankton production and trophic transfer efficiency. We predict that nitrogen addition will stimulate phytoplankton production, resulting in higher energy mobilization and higher food web efficiency in fertilized lakes. As T-DOC and nitrogen inputs to boreal lakes will likely increase in the future, it is important to determine the factors that drive basal production and food web efficiency in these lakes.

32-O   Decomposing the effects of multiple pressures on invertebrate assemblages of boreal stream.

Richard Johnson [1] - *Brendan McKie* [1] - *David Angeler* [1] - *Leonard Sandin* [2] - *Simon Hallstan* [1]

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Catchment land use often results in multiple stressors affecting the structure and function of aquatic ecosystems, and therefore understanding how stressors interact to affect the biology of aquatic ecosystems is a major challenge for freshwater management. Using a field survey approach, we studied single and multiple pressures effects of agricultural land use on invertebrate assemblages in 77 lowland, boreal streams. A substantial amount of variability in species and trait composition was shared between the main pressures, agriculture and alterations of hydrogeomorphology (HYMO). Consequently, unravelling the unique effects of these two pressures on community composition was not possible using variation partitioning. However, analysis of individual trait variables showed responses of feeding, habitat preference and resistance to disturbance that were in line with our predictions. Collectively, our results showed that unravelling pressure impacts and biological responses under high ecological realism of field studies is difficult and complicated by covariance between pressures, but that species and trait composition show promise in the detection of different types of impairment.

32-O   Bottom-up effects of flow reduction impact juvenile brown trout survival and condition in a multiple-stressor experiment.   _Andreas Bruder_ [1] - _Romana Salis_ [2] - _Peter Jones_ [2] - _Christoph Matthaei_ [2]

University of Applied Sciences and Arts of Southern Switzerland, Institute of Earth Sciences, Canobbio, Switzerland [1] - _Department of Zoology, University of Otago, Dunedin, New Zealand_ [2]

Agricultural land use results in multiple anthropogenic stressors affecting stream ecosystems. Flow reduction due to water abstraction, elevated levels of nutrients and chemical contaminants are key agricultural stressors worldwide. Interactions among multiple co-occurring stressors result in biological responses that cannot be predicted from single stressor effects (i.e. synergisms and antagonisms). At the ecosystem level, multiple stressor effects can be further modified by biotic interactions (e.g. trophic interactions). We conducted a field experiment using 128 flow-through stream mesocosms to examine the individual and combined effects of water abstraction, nutrient enrichment and elevated levels of the nitrification inhibitor dicyandiamide (DCD) on survival, change in condition, gut content and prey abundance of juvenile brown trout (_Salmo trutta_). Flow velocity reduction decreased fish survival (-12 % compared to the control) and condition (-8 %), whereas effects of elevated nutrient and DCD concentrations and interactions among these stressors were not significant. Negative effects of flow reduction on fish survival and condition coincided with effects on fish gut content (-25 %) and benthic abundance of the dominant invertebrate prey (-30 %), suggesting a negative energetic balance driving fish mortality and condition decline. Mortality of fishes under reduced flow velocity increased significantly as maximal daily water temperatures approached the upper limit of their tolerance range, reflecting synergistic interactions between these two stressors. Our study highlights the importance of indirect stressor effects such as those transferred through trophic interactions, which need to be considered when assessing and managing fish populations and stream food webs under multiple anthropogenic stressors.

32-O   Do warmer temperatures exacerbate the impact of eutrophication on cyanobacteria?

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In many lakes and reservoirs climate warming, extreme weather events and eutrophication can commonly co-occur. Individually these stressors can both be detrimental and beneficial, depending on what component of the community is considered. The response of specific populations, communities or functioning to combinations of stressors is largely unknown, although more often than not it has been found that stressors interact resulting in 'ecological surprises'. Of particular interest is the response of cyanobacteria, which can have major impacts on water resources, specifically their use for water supply and recreation. Cyanobacteria respond favourably to nutrient enrichment and warming and it is anticipated that the co-occurrence of these stressors will further favour cyanobacteria dominance. Few studies have empirically tested the interactive effects of multiple anthropogenic stressors on cyanobacteria and none have included other global change stressors known to control bloom dynamics, such as changes in lake retention time. To explore their response to these multiple stressors we performed a 12 month shallow lake mesocosm (3000L capacity) experiment consisting of two temperature levels (ambient, +4°C), two nutrient levels (control, enriched) and two 'extreme rainfall event' levels (control, flushed). Similar to previous research we found that: 1 nutrients and warming both stimulate growth whilst flushing reduces biomass and 2 of the two positive drivers, nutrients are relatively more important in explaining cyanobacteria biomass. As expected, warming and nutrients both dampened the effect of flushing, however, unexpectedly we found that warming interacts antagonistically with nutrients, reducing biomass. Provisional results from a compositional analysis indicate a community shift from cyanobacteria in hypereutrophic treatments to green algae when warming and nutrients interact. This interaction between warming and nutrients is contrary to predictions. Possible reasons for this discrepancy will be discussed and will consider the different mechanisms of warming as a stressor in lakes of different mixing regimes and also differing nutrient gradients. Our results suggest that in shallow, polymictic lakes, warming may not interact with nutrients to stimulate cyanobacteria dominance as detrimentally as predicted, however, importantly, nutrients was still clearly the driving factor of both

phytoplankton and cyanobacteria growth, sustaining high biomass even with the dampening effect of higher temperatures. This suggests that in shallow lakes the emphasis of bloom mitigation should continue to be on controlling nutrient enrichment.

32-O   Impacts of temperature on microbial decomposers along a gradient of silver nanoparticles stress.   *Daniela Batista, Cláudia Pascoal, Fernanda Cássio*

Centre of Molecular and Environmental Biology (CBMA)/ Institute for Science and Innovation for Bio-sustainability (IB-s), University of Minho, Braga, Portugal

The growing production of silver nanoparticles (AgNPs) makes inevitable their release into the freshwater ecosystems. AgNPs and ionic Ag derived from NPs, can have toxic effects on aquatic species and compromise important processes such as organic matter turnover, even at environmentally realistic concentrations. Plant litter decomposition is an important ecosystem process promoted by microbial decomposers, which serves as intermediaries between plant litter and higher trophic levels. AgNPs impacts have been the focus of much research, but their effects under different environmental scenarios, such as increasing water temperature are difficult to predict. It is probable that the combined effect of AgNPs and changes in water temperature may have strong impacts on the processes in which microbial decomposers are involved, further compromising the functioning of freshwater ecosystems. The goal of this study was to evaluate the interactive effects of AgNPs and temperature on the activity and diversity of microbial decomposers of plant litter in streams. Litter-associated microbial communities were exposed to increasing concentrations (8 levels) of AgNPs (50 to 75.000 µg L^{-1}) and AgNO$_3$ (5 to 7500 µg L^{-1}). Sets of microcosms were kept at 10ºC, 16ºC and at 22ºC. Leaf mass loss, fungal biomass and reproduction as well as microbial diversity were determined after 21 days. Also, the stress induced by AgNPs and Ag$^+$ on litter-associated microbial communities was assessed by measuring the activity of extracellular enzymes. Leaf mass loss was stimulated by the increase in temperature, while fungal biomass and reproduction were not. Increased AgNPs and AgNO$_3$ concentrations inhibited fungal biomass, particularly at the highest temperature. The activities of extracellular enzymes phenoloxidase and ß-glucosidase were generally higher at 22ºC. Fungal diversity decreased with increased AgNPs and AgNO$_3$ concentrations. Cluster analysis of DNA fingerprints showed that fungal and bacterial communities were affected by temperature and exposure to AgNPs and AgNO$_3$. These results suggest that temperature change events in streams may exacerbate AgNPs and AgNO$_3$ impacts on microbial decomposer activity further compromising the functioning of freshwater ecosystems.

32-O   Generation and survival of uniform patterns of phytoplankton-structure in multi-stressor systems.   *Yury Kamenir*

Bar-ilan Univ., University, Ramat-gan, Israel

The aim of this study was a search for typical patterns of phytoplankton assemblage structure and mechanisms explaining such pattern generation and persistence. A long-term analysis of taxonomic and ataxonomic size structure patterns of integral phytoplankton assemblages and main phyla of lacustrine phytoplankton was carried at considerably different aquatic ecosystems. Several types of statistical distributions - rank-frequency, Preston, ataxonomic biomass size spectra (BSS and NBS), traditional and modified taxonomic size spectrum (TTSS and FTSS) - were applied to find reliable patterns suitable for ecological forecast. The subsequent quantitative assessment of the pattern similarity was performed with the help of linear regression, correlation and cluster analyses. Long-term monitoring revealed the emergence and reestablishment of very similar distribution patterns of the whole phytoplankton assemblage and its main phyla, in spite of seemingly random changes in the species list.The FTSS general-pattern consistency was found for major phytoplankton phyla during the Kinneret 'stable' period. This consistency declined during the following 'extreme' years characterized with evident changes in phytoplankton taxonomic composition and annual succession. Some phyla were notably sensitive to environmental changes; therefore, they can be used as helpful diagnostic means. Specific changes in the fine structure of FTSS and rank-frequency distributions were evident and may be applicable for diagnostics, while the general patterns can be helpful for monitoring and modeling. The log-normal distribution and 1/f-noise seem to be suitable for explanation as multi-stressor mechanisms of generation and persistence of specific patterns rather often found in numerous fields of science including aquatic ecology. Such patterns can be applied to establish quantitative indices characterizing the stability-variability of the integral assemblage dynamics. Such reliable patterns of structure of natural aquatic assemblages can become powerful tools of lake management.

32-O   When parasites are good for health: learning from brine shrimps exposed to arsenic and avian cestodes.   *Marta I. Sánchez [1] - Inès Pons [1] - Mónica Martínez-Haro [2] - Mark Taggart [3] - Thomas Lenormand [4] - Andy J Green [1]*

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Parasites and pollutants can both affect any living organism, and their interactions can be very important. To date, repeated studies have found that parasites and heavy metals or metalloids both have important negative effects on the health of animals, often in a synergistic manner. Here, we show for the first time that parasites can increase host resistance to metalloid arsenic, focusing on a clonal population of brine shrimp from the contaminated Odiel and Tinto estuary in SW Spain. We studied the effect of cestodes on the response of *Artemia* to arsenic (acute toxicity tests, 24h LC_{50}) and found that infection consistently reduced mortality across a range of arsenic concentrations. An increase from 25ºC to 29ºC, simulating the change in mean temperature expected under climate change, increased arsenic toxicity, but the benefits of infection persisted. Infected individuals showed higher levels of catalase and glutathione reductase activity, antioxidant enzymes with a very important role in the protection against oxidative stress. Levels of TBARS were unaffected by parasites, suggesting that infection is not associated with oxidative damage. Moreover, infected *Artemia* had a higher number of carotenoid-rich lipid droplets which may also protect the host through the "survival of the fattest" principle and the antioxidant potential of carotenoids. This study illustrates the need to consider the multi-stress context (contaminants and temperature increase) in which host-parasite interactions occur.

32-O   Measuring the combined effects of temperature and nutrient enrichment on hyporheic respiration using flow-through chamber.   *Nataša Mori [1] - Tjaša Kanduč [2] - David Kocman [2] - Tatjana Simčič [1]*

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Heterotrophic respiration of river bed sediments is one of the key ecosystem processes in lotic ecosystems enabling the carbon fluxes in the river to landscape continuum. The measurement of oxygen consumption is the most frequently used method in studies of metabolism. In the climate warming scenario, water temperature and nutrient concentrations are expected to increase while their synergistic effects on the stream metabolism are poorly known. In this study the effects of water temperature and nutrient concentrations on the hyporheic respiration were investigated. The sediment samples were taken in the field on three occasions (summer, autumn, winter) and from two locations (reference and impacted site). The low nutrient water was obtained from the spring upstream of the reference site (mean nitrate concentrations - 1 mg L^{-1}) and high nutrient water from the impacted site (mean nitrate concentrations - 7 mg L^{-1}). The oxygen consumption was measured in the laboratory using flow-through chamber. Additionally, water chemistry and dissolved organic and inorganic carbon (DOC, $\delta^{13}C^{DIC}$) were measured at the inflow and outflow of the respiration chamber. Mean $\delta^{13}C^{DIC}$ values at inflow were -4‰ and -9.1‰ for low and high nutrient water, respectively, and were generally lower at outflow (-6 and -10‰). Mean DOC values were higher at outflow for low nutrient water and lower for high nutrient water when comparing to inflow water. The mean respiration rates were the highest in the samples taken in summer (0.46 mg O_2 gDW^{-1} h^{-1}). The significant effect of temperature ($p<0.5$) and nutrients ($p<0.1$) was observed for summer samples for both locations (two-way ANOVA). No significant effects of increased temperatures and nutrients were observed for autumn and winter samples suggesting the seasonal differences in response ranges of hyporheic respiration to temperature and nutrients.

32-O   How does climate change affect the response of cyanobacteria to nutrients?   *Laurence Carvalho* [1] - *Stephen Thackeray* [2] - *Rita Adrian* [3] - *Orlanne Anneville* [4] - *Meryem Beklioglu* [5] - *Hannah Cromie* [6] - *Seyda Erdogan* [5] - *Marko Jarvinen* [7] - *Stephen Maberly* [2] - *Yvonne McElarney* [6] - *Jannicke Moe* [8] - *Giuseppe Morabito* [9] - *Peeter Nõges* [10] - *Tiina Nõges* [10] - *Nico Salmaso* [11] - *Tom Shatwell* [3] - *Helen Woods* [1]

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It is widely believed that climate change acts synergistically with eutrophication to exacerbate the problems of algal blooms in lakes. This theory is based on the positive direct effects of higher temperatures and reduced rainfall (long retention times) on phytoplankton growth and loss processes. However, changes in temperature and rainfall have many indirect effects on phytoplankton, through effects in the catchment, lake physics and water quality and other communities that compete with, or consume, phytoplankton. This multitude of factors make it difficult to predict whether the effects of multiple stressors will be additive, synergistic or antagonistic. One approach for unravelling this complexity is to examine responses in long-term lake monitoring datasets.
Here we present results from 26 European lakes, sampled for at least 10 years between 1964 and 2014. In total 705 lake years of data were analysed, using Generalised Linear Mixed Models (GLMM), to examine the effects of three stressors (total phosphorus (TP), temperature and retention time) acting individually and their interactions. The analysis examined responses in the whole dataset (global model) and in lakes individually.
The most striking result was the large among-lake variability in responses to the three stressors. In the global model, spring TP had a significant positive effect on summer cyanobacteria biovolume. Weak negative relationships were observed in a few time series, although this was largely due to short TP gradients over a lake's monitoring period or sites where other factors limit algal biomass (e.g. in hypertrophic lakes). Both mean summer temperature and the frequency of "extreme" temperatures (the no. of summer days when daily averages exceeded 20 °C; Days>20°C), showed weak relationships with cyanobacteria. At the individual lake level, correlations between cyanobacteria biovolume and Days>20°C were generally more positive than relationships with mean summer temperatures, but relationships were generally not significant and there were some negative relationships. Responses to summer retention time were similarly weak in the global model and very variable at the individual lake level. We found no significant interactive effects of stressors on cyanobacteria abundance. Further analysis examines whether there are clearer responses to multiple stressors in particular functional lake types (e.g. deep-stratified vs shallow-mixed). In summary, the analysis highlights the significant effect of TP in driving potentially harmful blooms of cyanobacteria and suggests that, in general, summer air temperatures could have a smaller effect on this relationship than has previously been suggested. It does, however, also highlight that management needs to incorporate sensitivities at an individual lake level, as both strong synergistic and antagonistic relationships are apparent in some lakes.

32-O   Amplified toxicant effect caused by additional stressors.   *Matthias Liess*

UFZ - Helmholtz Centre For Environmental Research, System ecotoxicology, Leipzig, Germany

Anthropogenic toxicants are a major factor contributing to the biodiversity crisis: the decline of amphibians, loss of wild bees, honeybees; and the decline of aquatic biodiversity. These effects in the wild are often observed at unexpected low doses were the established risk assessment framework is not predicting a biological responses. Additional stressors have been identified as a major cause for these amplified toxicant effects. The talk reviews aquatic studies that empirically identified toxicant effects in the presence of additional stressors. These studies reveal that the combined effects of toxicants and additional stressors synergistically exceed the additive effects of individual stressors. Accordingly, environmental stress, as food deficiency, that alone may not exert significant effects can magnify toxicant-related mortality.

32-O   Arsenic contamination overrides eutrophication in causing catastrophic changes in lake ecosystems.   *Guangjie Chen* [1] *- Jianshuang Tao* [1] *- Haibin Shi* [1] *- Li Chen* [1] *- John P. Smol* [2]

Lab of Plateau Geographical Processes & Environmental Change, School of Tourism & Geography, Yunnan Normal University, Kunming, China [1] *- Paleoecological Environmental Assessment and Research Lab, Department of Biology, Queen's University, Kingston, Canada* [2]

Heavy metal pollution is now widely recognized to pose severe health and environmental threats, yet much of what is known concerning its adverse impacts on ecosystem health is derived from short-term ecotoxicological studies. Due to the frequent absence of long-term monitoring data, little is known of the long-tem ecological consequences of pollutants such as arsenic and their interaction with eutrophication in driving lake ecosystems. Here, our dated sediment records from two contaminated lakes faithfully document a 13.9 and 21.4-fold increase of total arsenic relative to pre-1950 background levels. Concurrently, coherent responses in keystone biota signal pronounced ecosystem changes, with a > 10-fold loss in crustacean zooplankton and > 5-fold increase in a highly metal-tolerant alga. Eutrophication was an obvious stressor in our study lakes during the last few decades; however, it cannot account for the abrupt ecosystem shift in our arsenic-polluted lakes. The nutrient role was overridden by the detrimental effects of arsenic contamination when a threshold level of arsenic concentrations was reached. Such fundamental ecological changes due to arsenic pollution will cascade through the ecosystem, causing potentially catastrophic consequences for ecosystem services in contaminated regions.

32-O   Riparian vegetation as indicator of river morphological adjustments.   *Bruna Gumiero , Giovanna Puppi*

Department of Biological, Geological and Environmental Sciences, University of Bologna, Bologna, Italy

Disturbance affecting flow and sediment dynamics can influence vegetation dynamics and composition so consequently they could be good indicators of channel adjustments and environmental conditions. Relationships and feedbacks between river morphology and vegetation were investigate by combining an analysis of morphological channel changes with a wider phytosociology analysis of existing vegetation within the river corridor. More specifically we analyzed: i) the relations between landforms and distributional patterns of vegetation types and characteristic plant species (index species): these provided information about the hydrogeomorphic condition of fluvial landforms and about channel adjustments; ii) the distance of riparian vegetation conditions from expected conditions as a consequence of human impact, based on the fact that each species and vegetation type has a given tolerance for specific disturbance regimes or stresses. In particular, the index species can give indications on present ecological conditions and on past channel evolution. With this knowledge it could might be possible to develop botanical recovery models in the future and, even more importantly, enable the recognition of the differences between temporal and spatial diversity. The investigation was done in a deeply incised and narrowed river in the Northern Apennines of Italy.

32-O   Species diversity delays adaptation to insecticides.   *Jeremias Becker, Matthias Liess*

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Insecticide resistance has been often described in pest species, but rarely studied in non-target species. However, insecticides shape the community composition of macroinvertebrates in agricultural streams on a large scale. Therefore the potential and the consequences of adaptation to insecticides may be vital for sensitive species.
Resistance alleles are highly beneficial under toxic conditions but are typically associated with fitness costs in a non-toxic environment. This enables the genetic recovery of a partly resistant population when insecticide exposure has stopped. We showed experimentally that interspecific competition between susceptible and resistant individuals accelerates the spread of resistance alleles under toxic conditions, and accelerates the decrease of the alleles under non-toxic conditions. Species interactions reduced intraspecific competition and thus delayed the adaptation of mosquito populations to both toxic and non-toxic conditions.
Based on these results, we hypothesized that species interactions may hinder the development of insecticide resistance in populations that are embedded in diverse communities. We detected low levels of insecticide resistance in numerous

macroinvertebrate species from agricultural streams in Germany. As predicted, the survival at high test concentrations increased when the macroinvertebrates derived from populations characterized by high intraspecific competition and low intensity of species interactions.

The results indicate that species living in diverse communities have a lower potential for adaptation to external stressors and are therefore particularly endangered by insecticides. Highly sensitive species become locally extinct already at low levels of exposure, facilitating the adaptation of the remaining species that are more tolerant. Without counteraction, this may result in depleted communities with few competition-driven populations that can develop high levels of resistance, as known from agricultural pests in monocultures.

32-O   Do persistent organic pollutants stimulate cyanobacterial blooms?   *Ted Harris, Val Smith*

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The use of persistent organic pollutants (POPs), such as herbicides, pesticides, pharmaceutical and personal care products (PCPPs), and polycyclic aromatic hydrocarbons (PAHs), has more than doubled since 1950. POPs find their way into aquatic ecosystems through agricultural and industrial runoff, wastewater treatment effluent discharge, and atmospheric deposition. Cyanobacterial Harmful Algal Blooms, which can produce toxins potent enough to cause human death, have been increasing in intensity, frequency, and spatial scale throughout the same time period as accelerated POP usage. Here, we provide a meta-analysis and suggest that POP stressors may be significantly aggravating nutrient-driven harmful cyanobacterial blooms by suppressing the growth of competing phytoplankton, and/or by indirectly or directly stimulating cyanobacterial growth.

32-O   Understanding the role of upstream refuge areas to compensate pesticide effects on stream invertebrates.   *Saskia Knillmann, Polina Orlinskiy, Ronald Muenze, Matthias Liess*

Ufz- Helmholtz- Centre for Environmental Research, Leipzig, Germany

Pesticides from agricultural land use cause major impacts on freshwater invertebrate communities worldwide. Upstream refuge areas along headwater streams have been observed to alleviate pesticide effects up to several kilometres downstream. However, there is only little knowledge about the underlying mechanisms of refuge areas along streams. We monitored 16 sampling sites in headwater streams in Central Germany. Here we identified the recovery dynamics of different macrozoobenthos taxa until the next pesticide application period. Pesticide exposure was measured using event-driven and passive sampling methods. The toxicity of the detected pesticide mixture caused a reduction in pesticide vulnerable taxa independently of the presence of upstream refuges. The majority of pesticide vulnerable taxa were observed to recover within one year to the level before contamination. In contrast, this site-specific recovery was not observed for most vulnerable taxa, if upstream refuges were absent. The presence of refuges seems to especially enhance the presence and recovery of taxa downstream that are able to migrate and drift over a certain distance. Hence, the analysis of community endpoints and single taxa dynamics over one year enabled a better understanding of upstream refuge areas and their role to compensate pesticide effects. This knowledge is essential for the implementation of mitigation measures in agricultural landscapes and for a sustainable land use management in general.

32-O   Climate change and hypoxia – ecophysiological traits underpinning the vulnerability of aquatic insects to warming.   *Wilco Verberk*

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Aquatic ecological responses to climatic warming are complicated by interactions between thermal effects and other environmental stressors such as organic pollution and hypoxia. Oxygen is essential for burning food, but may become limiting for organisms relying on gas exchange under water. This is because breathing under water is challenging: the diffusion of oxygen is orders of magnitude lower in water than in air, while the higher density and viscosity of water greatly enhance the cost of breathing.

Laboratory experiments have demonstrated how oxygen limitation can set heat tolerance for some aquatic ectotherms, but only at unrealistic lethal temperatures and without field data to assess whether oxygen shortages might also underlie sub-lethal warming effects. Analyses of extensive field data show for the first time that oxygen limitation is also important at realistic, sub-lethal temperatures for aquatic insects: Hypoxia and warming clearly amplified each other's impact. The broad concordance shown here between laboratory results and field data suggests that oxygen limitation not only limits survival at thermal extremes but also restricts species abundance in the field at temperatures well below upper lethal limits, possibly because oxygen becomes limiting for growth and reproduction in warmer water. A comparison between species pairs spanning four different insect orders, reveals that species with limited ability to regulate oxygen uptake (i.e. tegument breathers) were consistently more vulnerable to the synergistic effects of warming and hypoxia than those with good respiratory control (e.g. air breathers). This indicates that mode of respiration is a key ecophysiological trait, which together with water oxygenation controls the vulnerability of aquatic ectotherms to global warming. Improving water oxygenation and reducing pollution thus provide key facets of climate change adaptation for aquatic ecosystems.

32-O   How the phytoplankton community in shallow lakes with contrasting temperatures and nutrient level respond to a heatwave: a mesocosm experiment.   *Nur Filiz [1] - Erik Jeppesen [2] - Yu Cao [2] - Erika M. Neif [3] - Jan Coppens [1] - Tom A. Davidson [2] - Martin Søndergard [2] - Torben L. Lauridsen [2] - Meryem Beklioğlu [1]*

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Phytoplankton are short-lived organisms responding fast and directly to environmental fluctuations which makes them useful indicators of deterioration in lake ecosystems to stressors. Due to climate change, extreme events including heat waves and flooding will be more common in the future and such changes also augment eutrophication, a problem lakes already is facing today.

To understand the effects of temperature and nutrient stressors on phytoplankton taxonomic groups and size diversity we conducted a mesocosm experiment in Silkeborg, Denmark –a system- which has been already continuously operated for 11 years. There are 24 mesocosms (1.9 m in diameter, 1.5 m in total depth, imitating a shallow lake) simulating two nutrient levels (unenriched and enriched with additional nitrogen and phosphorus) and three different temperature scenarios (ambient, IPCC A2 scenario and A2+%50) with 4 replicates. Heat wave was imitated for 1 month by rising the temperature 5°C (from 1st July till 1st August 2014). During this period samplings were done twice a week, and later less frequently. Phytoplankton was identified, biovolume and size diversity calculated. Using also physico-chemical variables from the mesocosms, the effects of the extreme heatwave on the phytoplankton community and structure at contrasting nutrient levels will be analysed and discussed.

32-O   Multiple stress of eutrophication and climate change in lakes: projected effects of future climate scenarios for phytoplankton in northern European lakes.   *Jannicke Moe [1] - Anne Lyche Solheim [1] - Niina Kotamäki [2] - Hege Gundersen [1] - Laurence Carvalho [3] - Birger Skjelbred [1] - Marko Järvinen [2] - Geoff Phillips [4]*

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The aim of this study is to assess the impact of nutrients in combination with climatic stressors on lakes in Northern Europe based on phytoplankton indicators, under current and future conditions. Eutrophication and climate change are considered an important stressor combination for lakes in most parts of the world. High concentrations of total phosphorus (TP) in combination with increased temperature tend to benefit growth of phytoplankton, and in particular cyanobacteria, which can result in harmful algal blooms. In this study, we used monitoring data from ca. 800 lakes in United Kingdom, Norway, Sweden and Finland (in total ca. 2000 lake-years). The data were compiled during the past EU project WISER and are being modelled in the on-going EU project MARS (2014-2018).

The first step was to quantify the empirical relationships between phytoplankton indicators (cyanobacteria, biomass and the Phytoplankton Trophic Index), nutrients (primarily TP) and climatic variables (temperature, precipitation and

wind) and other lake characteristics (including typology factors such as mean depth, surface area, altitude, alkalinity and humic level). A hierarchical regression model was used account for lake types and for repeated measurements from lakes (lake-years). Following the conceptual model DPSIR (driver-pressure-state-impact-response), we also attempted to link the nutrient concentrations to drivers (population density and land use) and pressures (nutrient loads).

The second step was to construct a parametric model constructed based on the quantified relationships. The purpose of this model was to predict the ecological status of the lakes based phytoplankton indicators under different future scenarios of climate and potentially land use. Preliminary assessment by this model has indicated the risk of cyanobacteria concentrations exceeding an acceptable limit increases with higher temperature but decreases slightly with more precipitation. In the current assessment, more realistic future scenarios will be applied for each individual lake. Here we use future projections for climate and land use for the years 2030 and 2060, which are generated on a 0.5 degrees grid for all of Europe. The projections are based on the 3 storylines defined by the MARS project ("Techno world", "Consensus world", "Fragmented world"), which combine different climatic and socio-economic scenarios.

32-O   Can dam sediment removal activities really be sustained by aquatic biota in alpine river catchments?   *Maurizio Battegazzore*

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For the functioning of stream communities, the continuity of upstream and downstream reaches is a vital concern for the protection of aquatic biota, especially considering that this continuity can be and is disrupted by human activities. For example, barriers to the migration of fish and invertebrates may be caused by reduced water flow due to abstraction, by pollution, or most notably by dam construction which may interrupt the river continuum (the serial discontinuity concept of Ward and Stanford, 1983). Traditional ways of sediment removal from within reservoirs to maintain dam functionality have been and still represent a significant physical impact and interruption of river continuity, especially in some Italian Alpine catchments, which are also ecologically vulnerable. Examples of adverse effects of intensive loading of sediments are those observed on phytobenthic, macroinvertebrate and fish communities. Studies showed that progressively long times of recovery are necessary for the mentioned communities following strong sediment releases from dams.

A strong trend of decreased construction has occurred in some parts of the world in recent decades. In North America 993 large dams were erected between 1961 and 1980, but only 64 have been built since 1981. In recent years increasing demolition of dams is evident in advanced countries (20-50 dams removed annually in the USA between 2005 and 2015. The main reason appears to be an increased public awareness of the need for restoring ecological functionality of rivers and also the possibility of allowing their recolonization by fish including salmon. In Europe signs of such a change in dam construction trend may be observed (e.g. in UK, France) but in Italy a similar process has not started. Possible improvements in the environmental effects of dam sediment management can be obtained by:

1) Evaluating the real need and for new and existing hydroelectric dams and deciding, in agreement with local communities, which reservoirs are necessary and sustainable for the purpose of the restoration of more natural river conditions;

2) Improving current procedures including synchronization between functional emptying of reservoir bedloads and security operations both in long term planning and short term removal projects and adopting biological monitoring methods specifically aimed at physical disturbance evaluation,

3) Introducing innovative technologies where feasible aimed at the continuous release of sediment from the dams as opposed to the current practice of accumulation which is one of the main causes of concern and damage to the downstream reaches both in terms of aquatic communities and water use. In particular, technologies which allow a more and natural and continuous outflow of sediments should be introduced, at first experimentally, and expected beneficial effects should be monitored with the aim of extending them to all existing dams where this type of improvement is possible.

32-O   Pre dam studies in Monday River, Eastern Paraguay.   *Juan F Facetti-Masulli* [1] - *Carmelo López* [2] - *Francisco J Schade* [3] - *Amado González* [4]

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Monday River, at Eastern Paraguay is located south of the Itaipu Dam, and discharges into the Paraná River. At the point of discharge it has been projected to build a Hydroelectric Power Plant and the reservoir will extend upstream the Monday.

As a result of the impoundment of a river, the flooded soil can provide a certain amount of nutrients into the aqueous medium setting new conditions for aquatic life and affecting TO a greater or lesser degree the ecosystems. The aim of this work is the assessment of the impact on the water quality of the incorporation of major nutrients into the water body after damming of the Monday River.

Samples from soil profiles were taken at selected sites on both banks of the river; the amount of phosphorus, nitrogen, potassium, calcium and magnesium as well as other parameters as pH, organic matter, exchangeable bases were determined using standard procedures. Granulometric analysis were also performed. Exchangeable phosphorus was determined by isotopic exchange with P-32. In addition the samples were submitted to submersion/incubation experiments along 60 days, and the concentration of elements incorporated into the water analyzed. Results show that flooded soils are low in phosphorus, and nitrogen; so does other nutrients. Submersion experiments also indicate generally limited incorporation of such nutrients into the water body. Negative impacts of these soils on water quality are not to be expected.

33. POLAR AND ALPINE LAKES AS SENTINELS OF ENVIRONMENTAL CHANGE

33-O   Subglacial Lake Whillans: an active ecosystem beneath the Antarctica ice sheet. _John Priscu_ [1] - _Amanda Achberger_ [2] - _Brent Christner_ [3] - _Alexander Michaud_ [1] - _Mark Skidmore_ [1] - _Trista Vick-Majors_ [1]

Montana State University, Bozeman, United States [1] - _Louisiana State University, Baton Rouge, United States_ [2] - _University of Florida, Gainsville, United States_ [3]

Subglacial Lake Whillans is the first Antarctic subglacial lake to be sampled directly. Hot water drilling was used to access the water column and sediments of Subglacial Lake Whillans in January 2013 as part of the Whillans Ice Stream Subglacial Access Research Drilling (WISSARD) Project. The lake lies 800 m beneath the surface of the Whillans ice plain and had temperature, conductivity and pH values of -0.5 $^{\circ}$C, 720 μS/cm and 8.1, respectively. The lake had relatively high dissolved organic carbon (~2.5 mgC/L) and low dissolved oxygen (<3 mg/L). This oxygen level (16% of air saturation) indicates that metabolic sinks exceed sources in the lake. Molar particulate organic C to N ratios in the water column averaged 65, which are much higher than those in the sediments (~16). These C:N ratios reveal a system deficient in N relative to C. An δ18O value of -38.0 ‰ for the lake indicates that glacial ice melt water is the primary water source; Cl$^-$ to Br$^-$ concentrations and ratios suggest a minor seawater component. Conductivity and δ18O values in the upper 38 cm of lake sediment infer a seawater influence in the deeper sediment layers. Delta17O-nitrate values of the lake water averaged 0.8 ‰ indicating microbial production as the dominant source for SLW nitrate. Bacterial densities in the lake averaged 100,000/mL and contained diverse morphotypes. Radiolabeled substrate incorporation and ATP levels showed active biosynthesis in both the water column and surficial sediment layer. Bacterial growth efficiency, based on 14C-leucine incorporation, was 0.12. Small subunit rRNA gene sequences revealed that the lake water was dominated (81%) by phylotypes related to archaea within the Thaumarchaeota Marine Group I, a newly recognized group of chemotrophic ammonium oxidizers. Members of the Proteobacteria (Gamma, Beta, Delta), Planctomycetes, and Actinobacteria collectively represented 12% of the OTUs found in the water column. In contrast, only one archeal OTU was identified in the sediments (2 to 4 cm depth interval) and ~80% of the phylotypes identified were affiliated with the Proteobacteria. Many of the bacterial phylotypes were closely related to species that grow chemolithotrophically using reduced iron, sulfur, or nitrogen compounds or C1 hydrocarbons as electron donors and are presumably responsible for the relatively high levels of DOC within the lakewater. Collectively, our results indicate the presence of an active microbial community beneath the Whillans Ice Plain dominated by chemolithoautotrophs, which contribute to subglacial weathering processes.

33-O   Mechanisms of nutrients enclosure inside microbial mat in Antarctic oligotrophic lakes by combination approach of observation data and theoretical study.   _Yukiko Tanabe_ [1] - _Akiko Mizuno_ [2]

Biology Group, National Institute of Polar Research, Tokyo, Japan [1] - _Institute of Space-earth Envionmental Research, Nagoya University, Nagoya, Japan_ [2]

The most of water bodies of freshwater lakes in continental Antarctica are considered to be nutrients limited (Hawes et al. 1993). Our previous study on 17 fresh water lakes in Syowa region, Antarctica showed that although the nutrient concentrations of lake water are oligotrophic, the interstitial water of benthic microbial mats surface were 3-220 times higher in DIN (dissolved inorganic nitrogen) concentrations and 2-102 times higher in phosphate than that of the lake water (Tanabe et al. submitted). The nutrient concentrations of the interstitial water in Antarctic lakes are either equaling or surpassing that of temperate eutrophic lakes. Also, there are no correlations between the lake water and the interstitial water in Antarctica, which the nutrient concentrations of the interstitial water have a wide range of variations although lake waters are almost same concentrations among the lakes. Then, it is considered that there are any mechanisms the nutrients hardly discharged from lakebeds to water column in Antarctica such like nutrients enclosure. To reveal the mechanisms, we used vertical profiles of the silicate and phosphate concentration inside benthic mat cores collected from Antarctic freshwater lakes, and examined the following 2 factors considered as controlling nutrients enclosure by model study. The first factor is viscosity coating on the mats surface and inside mats, the second is uptake by phototorophs in mats surface layer.

We established two diffusion models to represent dynamics of silicate and phosphate in lake water and benthic mat on the vertical axis. The diffusion model combined with effect of mat viscosity and biological consumption was used to predict the distribution of nutrient concentration and was compared with observation data. In the silicate model, we can exclude biological consumption because there are remarkably few organisms using silicate in Antarctic lakes such as diatom. Then, we firstly estimated the effect of mat viscosity on the molecular diffusion using silicate model. The silicate model showed a wide range of variations of viscosity, and inherent values of the viscosity depending on each lake were obtained. Next we estimated the biological consumption using phosphate model with estimated mat viscosity by silicate model, then this indicated that the phototrophs surely take in phosphate in the mat surface layer. Our study by combination of theoretical and observational approach suggests that a mechanism of nutrients enclosure inside benthic mats in Antarctic oligotrophic lakes is caused by viscosity of the mats and uptake by phototrophs.

33-O Nutrients, organic matter and bacteria community composition at early stages of the proglacial lake of Ventisquero Negro (Mountain Tronador, Patagonia, Argentina).   *Beatriz Modenutti, Marcela Bastidas Navarro, Nicolás Martyniuk, Esteban Balseiro*

INIBIOMA-CONICET-UNCO, CONICET- Universidad Nacional del Comahue, Bariloche, Argentina

Climate change affects glaciers all over the world causing glacial recession with the formation of new lakes. These proglacial lakes are characterized by heavy glacial clay inputs that cause a turbidity-induced attenuation of photosynthetically active radiation (PAR), therefore they can be expected as environments with light limitation for primary producers. The aim of this study was to assess temporal shifts in nutrients, organic matter and bacteria abundance, diversity and respiration, in the proglacial lake of Ventisquero Negro located in Mountain Tronador (Patagonia, Argentina). Samplings were conducted during four successive austral summers (2012/15). We measured nutrient concentrations, bacteria abundances assessing different components of bacterial community structure using next-generation sequencing of the 16S rRNA gene. In addition we conducted experiments measuring oxygen consumption by bacteria communities and spectrofluorometric analysis of the dissolved organic matter. Results showed that chlorophyll a concentrations were low (0.571 ± 0.33 µg L^{-1}) because of the light limitation imposed by the high turbidity due to total suspended solids. Bacteria community analysis using the 16S rRNA gene identified a total of 2135 OTUs consisting mainly of Proteobacteria, Firmicutes, Actinobacteria and Bacteroidetes. Dissolved organic carbon (DOC) concentrations in the lake were low (0.43 ± 0.16 mg L^{-1}) and analyses indicated the presence of two components one corresponds to protein-like and the other to humic-like substances. Ice presented higher DOC concentration (1.6 ± 0.18 mgL^{-1}) than the lake and analyses showed the dominance of protein-like component. High bacteria respiration rates were attained in coincidence with the presence of one protein-like component in the dissolved organic matter, while no relationship was observed between bacteria respiration and chlorophyll a concentration.

33-O Equatorial pro-glacial lakes: are they different from their higher latitude homologues?   *Dean Jacobsen , Kirsten Seestern Christoffersen*

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Due to glacial retreat, the number of pro-glacial lakes is currently growing worldwide. The relatively few studies that have been performed on the ecology of this dynamic lake type are from arctic-temperate latitudes, and reveal biologically very poor ecosystems due to environmental harshness. Hitherto, virtually nothing is known about proglacial lakes in the tropics. They are generally not exposed to ice-cover, but to extreme UV radiation and low oxygen availability at very high altitude. Here we present the results of a survey of a number of proglacial lakes in Ecuador. We were especially interested in the pelagic versus benthic biomass and biodiversity along a gradient in turbidity from suspended "glacial flour" (fine mineral particles) as an expected environmental key factor. Biological features of the equatorial pro-glacial lakes did, however, not seem to be greatly determined by turbidity, as even clear lakes with only indirect glacial influence were very poor. Factors related to the extreme altitude seem to be more important in structuring the biological structure of these lakes.

33-O   Perspective for an integrated understanding of tropical and temperate high-mountain lakes.

Jordi Catalan [1] - *John Donato* [2]

CREAF, CSIC, Bellaterra, Spain [1] - *Departamento De Biología, Universidad Nacional de Colombia, Bogotá, Colombia* [2]

High mountain lakes are extreme freshwater ecosystems and excellent sentinels of current global change. The largest contrast occurs between lakes in temperate and tropical areas. The main difference arises from the seasonal patterns of heat exchange and the external loadings (carbon, phosphorus, metals). The consequence is a water column structure based on temperature, in temperate lakes, and oxygen, in tropical lakes. This essential difference implies that in tropical lakes one can expect a more sustained productivity throughout the year; a higher nutrient internal loading based on the mineralization of external organic matter; higher nitrification-denitrification potential related to the oxyclines; and larger metal mobilization due to the permanently reduced bottom layer. Quantifying and linking these and other biogeochemical pathways to particular groups of organisms is in the current agenda of high-mountain limnology. On the other hand, the intrinsic difficulties of the taxonomic study of many of the organisms inhabiting these systems can be nowadays overcome with the use of molecular techniques. These techniques will not only provide a much less ambiguous taxonomic knowledge of the microscopic world but also will unveil new biogeochemical pathways that are difficult to measure chemically and will solve biogeographical puzzles of the distribution of some macroscopic organism, tracing the relationship with other world areas. We propose that limnological studies at tropical and temperate high mountain lakes should adhere to a common general paradigm. In which biogeochemical processes are framed by the airshed-to-sediment continuum concept and the biogeographical processes in the functional lake district concept. The solid understanding of the fundamental limnological processes will facilitate stronger contributions to the assessment of the impacts of the on-going global change in remote areas.

33-O   When glaciers melt: consequences for lake diversity and function.   *Ruben Sommaruga, Hannes Peter*

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Global climate change is causing a rapid wastage of glaciers and threatening biodiversity in glacier-fed ecosystems. The high turbidity typically found in those ecosystems, which is caused by inorganic particles and result of the erosive activity of glaciers is a key environmental factor influencing temperature and light availability, as well as other factors in the water column. Once these lakes loose hydrological connectivity to glaciers and turn clear, the accompanying environmental changes could represent a potential bottleneck for the established local diversity with yet unknown functional consequences. Here, we study three lakes situated along a turbidity gradient as well as one clear unconnected lake and evaluate seasonal changes in their bacterial community composition and diversity. Further, we assess potential consequences for community functioning. Glacier runoff represented a diverse source community for the lakes and several taxa were able to colonize downstream turbid habitats, although they were not found in the clear lake. Operational taxonomic unit-based alpha diversity and phylogenetic diversity decreased along the turbidity gradient, but metabolic functional diversity was negatively related to turbidity. No evidence for multifunctional redundancy, which may allow communities to maintain functioning upon alterations in diversity, was found. Our study gives a first view on how glacier-fed lake bacterial communities are affected by the melting of glaciers and indicates that diversity and community composition significantly change when hydrological connectivity to the glacier is lost and lakes turn clear.

33-O   Long-term changes in the ionic composition of Italian alpine lakes, in relation with climate change.   *Aldo Marchetto* [1] - *Michela Rogora* [1] - *Lyudmila Kamburska* [1] - *Rosario Mosello* [1] - *Gabriele A. Tartari* [1] - *Luca Paro* [2]

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To estimate the effects of climate change on the ionic composition of Alpine lakes, we compared the analysis performed in the 1980's and in the second decade of the 21th century on 47 high mountain lakes located in the Western and Central Alps, Italy.

In spite of a high lake-to-lake variability, a general increasing trend in conductivity and in most ionic concentrations was detected, particularly evident in the lakes with a higher solute content. An increase in the contribution of sulfate to the total ionic content was also found.

Changes in the ionic composition were more marked in lakes having rock glaciers and/or retreating glaciers in their catchments: present concentrations of major ions generally resulted more than twice the values of the 1980s in the formers, and up to 4 times in the latters.

To test the hypothesis that changes in snow and glacial cover in lake catchments were more important than temperature alone in affecting lake chemistry, we also analyzed the relationship between year-to-year variability in lake water chemical composition and selected meteorological variables in 4 lakes in Ossola Valley (Central Alps), sampled almost every year from 1978 to 2015.

Finally, a spring originating from a rock glacier and feeding one of these lakes was also studied in detail, to identify the effects of short-term meteorological variability on water chemistry.

33-O   Permafrost thaw makes subarctic lakes more terrestrial.   *Maxime Wauthy, Milla Rautio*

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Permafrost occupies a great proportion of the subarctic landscape. With climate change, this permafrost is thawing at an accelerated rate, promoting the formation of shallow ponds, the thermokarst (or thaw) ponds. These ponds have become increasingly abundant in subarctic areas, representing up to 90% of all lakes in some regions. Unlike the classical ultraoligotrophic freshwater systems found at high-latitudes, the thaw ponds are characterised with high turbidity, high nutrient content and high inputs of organic matter from the watershed and thawing permafrost. Therefore, the dissolved and particulate organic matter (DOM and POM) in thermokarstic ponds are expected to be mainly derived from terrestrial sources and be more allochthonous compared to the oligotrophic freshwater lakes. The aim of this study is to explore the impact of thawing permafrost on the DOM and POM composition of subarctic lakes. We hypothesise that allochthonous/autochthonous carbon ratio is higher in thermokarstic ponds in comparison to lakes that are not influenced directly by thawing permafrost. Field work was performed in subarctic shrub tundra on the eastern coast of Hudson Bay, near Kuujjuarapik-Whapmagoostui (Quebec, Canada) in August 2014 and 2015. We compared the origin of DOM and POM in six oligotrophic lakes (rocky and tundra ponds) and six thaw ponds through carbon (d13C) and deuterium (d2H) stable isotope analyses. We also investigated the source of DOM using the coloured dissolved organic matter (CDOM) fluorescence components. Preliminary results indicate that DOM and POM have d13C and d2H signatures closer to terrestrial sources in thaw ponds compared to lakes that are not influenced directly by thawing permafrost. CDOM analyses show the same profile, indicating a larger contribution from terrestrial humic substances in thermokarstic pond DOM. This study demonstrates the importance of thawing permafrost on terrestrial inputs in subarctic lakes. The increasing number of thermokarstic ponds also suggests that warming Arctic temperatures induce more allochthony in the northern freshwater ecosystems.

33-O   An experimental test to assess the effects of treeline shift on bacterial community composition and function in a subarctic lake.   *Carina Rofner [1] - Hannes Peter [2] - Núria Catalán [3] - Fabian Drewes [1] - Ruben Sommaruga [1] - María Teresa Pérez [1]*

Institute of Ecology, University of Innsbruck, Innsbruck, Austria [1] - Stream Biofilm and Ecosystem Research Laboratory, École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland [2] - Limnology, University of Uppsala, Uppsala, Sweden [3]

Lakes are excellent sentinels of climate change and can act as indicators of climate driven changes in the surrounding landscape and atmosphere. The expansion of terrestrial vegetation towards higher latitudes and altitudes entails long-term changes in soil development and composition and thus in the inputs of allochthonous carbon and nutrients to lakes. Those might in turn trigger shifts in aquatic microbial community structure and consequently in ecosystem functioning. Here, we studied the short-term response (72 h) of the bacterial community of an oligotrophic subarctic lake to climate driven changes in the catchment by simulating soil runoff with soil extracts of different origin. We determined bacterial community composition and diversity using catalysed-reporter-deposition fluorescence-*in-situ*-hybridization and 16S rRNA sequencing (Illumina), respectively, and measured bulk community and taxon-specific

uptake of inorganic (^{33}P-Pi) and organic (^{33}P-ATP) phosphorus, as well as ^{3}H-leucine bacterial production (microautoradiography). We hypothesized that extracts from soils located below the treeline will alter lake bacterioplankton community structure and alleviate bacterial P-limitation compared to soil extracts from the lakes own catchment. Bacterial community structure, diversity and function responded rapidly to soil extract additions, but differed as a function of the soil source. For instance, soil extracts derived from below treeline reduced inorganic and organic phosphorus uptake rates at the bulk community (range: 0.2-3.5 pM*h^{-1}) and taxon-specific (< 10% cells positive for Pi or ATP uptake) level along the entire experiment, indicating that bacterial P-limitation was alleviated. Whereas in treatments with soil extracts from above treeline, phosphorus uptake increased at the end and reached the control's values (~38 pM*h^{-1} Pi or ATP; 10-40% cells positive for either substrate). A rapid succession of bacterial phylotypes took place in both experiments suggesting that certain taxa directly benefited from soil extracts, whereas others may be stimulated by resources generated during the incubations. The dominance of initially rare bacterial taxa hints to niche-occupation and substrate-specialization of *Bacteroidetes* members (e.g., *Flavobacteriaceae*, *Sphingobacteriaceae*), whereas *Betaproteobacteria* (in particular *Oxalobactereaceae*) which increased in relative abundance at the end of the experiments, probably depended more on labile compounds and benefited from released degrading by-products. Our results highlight that there is strong linkage between the lake bacterial compartment and their surrounding terrestrial environment. We conclude that climate induced changes in soil development and composition will strongly affect bacterial community composition and function, altering the biogeochemical cycles of high latitude aquatic ecosystems.

33-O   Circulation and respiration in ice-covered Alaskan arctic lakes.   *Sally MacIntyre, Alicia Cortes, Steven Sadro*

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Arctic lakes are ice-covered 9 months of the year. During at least part of this time, the sediments heat the overlying water. Sediment respiration increases specific conductivity, depletes oxygen, and produces greenhouse gases (GHG). Whether anoxia forms and whether the greenhouse gases are sequestered at depth depends on processes inducing circulation and upward fluxes. Similarly, whether the GHG are released at ice off depends on the extent of vertical mixing at that time. Using time series meteorological data and biogeochemical arrays with temperature, specific conductivity, and optical oxygen sensors in 5 lakes ranging from 1 to 150 ha, we illustrate the connections between meteorological forcing and within lake processes including gravity currents resulting from increased density just above the sediment water interface and internal waves including those induced by winds acting on the surface of the ice and at ice off. We found that CO_2 production was well predicted by the initial rate of oxygen drawdown near the bottom at ice on and that the upward density flux depended on lake size, with values initially high in all lakes but near molecular in lakes of a few hectares in size by mid-winter. Both CO_2 production and within lake vertical fluxes were independent of the rate of cooling in fall and subsequent within lake temperatures under the ice. Anoxia formed near the sediments in all 5 lakes with the concentration of CH_4 dependent, in part, on lake size and depth. Inflowing snowmelt waters flowed under the ice with some mixing with underlying lake water. The loading of DOC and CH_4 depended on the rate of snowmelt. Twenty to fifty percent of the greenhouse gases produced under the ice remained in the lakes by the time thermal stratification was established in summer despite considerable mixing at the time of ice off. These observations and analysis lay a framework for understanding the links between within lake hydrodynamics, within year variability, and the fraction of greenhouse gases produced under the ice which evade at ice off.

33-O   Toolik Lake: a 40-year record of geochemical change in the arctic.   *George Kling [1] - George Kipphut [2] - Neil Bettez [3] - Jason Dobkowski [4] - Anne Giblin [5] - John Hobbie [5] - Gaius Shaver [5] - Vladimir Romanovsky [6]*

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Long-term data from the Arctic LTER site shows 40 years of geochemical change in Toolik Lake, and similar responses in nearby lakes. In this time the alkalinity of Toolik Lake has doubled, the Toolik inlet stream alkalinity has increased, and nearby lakes have also increased in alkalinity. In-lake alkalinity generation cannot account for the observed alkalinity

increase. Instead, evidence from stream water $^{87}Sr/^{86}Sr$ ratios indicates deeper hydrological flowpaths especially in the unfrozen zones beneath lakes and streams. Therefore, we believe that increased weathering in sediments beneath lakes and streams explains the dramatic geochemical change of doubling alkalinity over 40 years. However, this change has occurred despite the lack of a detectable increase in air temperature, and a lack of detectable increases in lake water temperatures or mean catchment thaw depth. Clearly this ecosystem is vulnerable to change, and apparently the ecosystem stressors causing the change are either hidden from our observational capabilities or as yet undiscovered. At the same time, permafrost temperatures in 20 m deep boreholes in the region are increasing, and there is a strong correlation between the permafrost temperature increase and the increase in alkalinity in Toolik Lake. It is possible that Fall season air temperature increases at Toolik and the increasingly later freeze up of soil active layers may be influencing late-season weathering and alkalinity inputs. Overall, one hypothesis is that these geochemical changes are integrating the effects of the climate signal on multi-year to decadal time scales; that is, they act as a medium-pass filter that reduces the signal variability yet allows the effects of long-term warming to emerge, as seen in the alkalinity and permafrost temperature records. Similar geochemical alterations may be occurring in unmonitored areas of the Arctic, even if soil thaw depth and climate drivers have stayed the same over time. In addition to these geochemical trends, terrestrial responses to climate change have recently resulted in dramatic land-surface disturbances in the form of thermokarst failures and tundra fires – such disturbances have the potential for alteration of aquatic geochemistry and may result in larger and more rapid transformations than will the steady trends of climate change.

33-O   Sunlight controls water column processing of carbon in Arctic freshwaters.   _Rose Cory_ [1] - _Collin Ward_ [1] - _Byron Crump_ [2] - _George Kling_ [3]

Department of Earth & Environmental Sciences, University of Michigan, Ann Arbor, United States [1] - _Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, United States_ [2] - _Ecology and Evolutionary Biology, University of Michigan, Ann Arbor, United States_ [3]

Carbon (C) in thawing permafrost soils may have global impacts on climate change, yet controls on its processing and fate are poorly understood. The dominant fate of dissolved organic C (DOC) released from soils to inland waters is either complete oxidation to CO_2 or partial oxidation and river export to oceans. Both processes are most often attributed to bacterial respiration, but we showed that photochemical oxidation exceeds rates of respiration and accounts for 70-95% of total DOC processed in the water column of arctic lakes and rivers.   While the overall dominance of photochemical processing in streams and lakes remained, the fate of DOC varied consistently by water type. In small streams DOC was mainly mineralized by sunlight to CO_2, while in lakes the main fate of DOC was partial photo-oxidation. Large rivers were intermediate between these end members, and photo-mineralization to CO_2 was about equal to or less than partial photo-oxidation. We suggest this pattern is a result of light-exposure history, where DOC leached from soils into headwater streams has little prior light exposure and is labile to complete photo-oxidation, but as light exposure increases moving downstream and into lakes with longer residence times the DOC photo-lability declines. Thus as easily photo-mineralized moieties are removed, DOC fate shifts toward partial photo-oxidation and downstream export in rivers and lakes. At the basin scale, photochemical processing of DOC is about one third of the total CO_2 released from surface waters, and is thus an important, newly measured component of the Arctic C budget. We suggest that these photochemical transformations of DOC will occur in any shallow surface water, and could be important for better understanding inland water carbon cycling.

33-O   Investigating wind as a vector for delivering seabird nutrients and contaminants to Arctic lakes.

Kathryn Hargan [1] - _Wenhan Cheng_ [1] - _Linda Kimpe_ [1] - _Mark Mallory_ [2] - _Grant Gilchrist_ [3] - _John Smol_ [4] - _Jules Blais_ [1]

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Energy and nutrient fluxes across ecosystem boundaries can exert profound direct and indirect effects on the dynamics of the recipient systems, especially in nutrient-poor environments like the Arctic. Digges Sound, located in Hudson Strait provides nesting habitat to one of the largest Thick-billed Murre colonies in Canada (~400,000 pairs). Little is known about the historical connection of these birds to the Arctic landscape and how they may impact the surrounding aquatic

ecosystems. Traditionally, paleolimnological studies tracking seabirds have relied on a landscape design where the seabirds nest within a lake's catchment and their wastes effectively drain into the recipient waterbody. Thick-billed Murres nest on cliffs above Hudson Strait and rarely fly overland. Therefore, for this study, we examined lake water chemistry and sediments using a large set of biotic and abiotic proxies to determine whether Arctic winds can distribute nutrients and contaminants from cliff-nesting seabirds to regional lakes. We have analyzed the water chemistry and diatom assemblages collected from rock scrapes of ~20 lakes located at increasing distance from the colony (~100 m to >1 km). These samples help identify the main water chemistry variables (e.g., nutrients, conductivity) structuring the modern assemblages of diatoms, as well as identify diatom species associated with bird impacted lake conditions. In addition to diatom assemblages, δ^{15}N of surface sediments further distinguishes sites receiving bird subsidies from reference sites. The analysis of four dated sediment cores, collected at varying distances from the seabird colony, for aquatic microfossils, sedimentary chlorophyll-*a*, stable isotopes, metals, and sterols has been completed to determine the long-term linkages between seabirds and aquatic food webs. Since the early 1990s, the region has undergone substantial climate-related changes including a reduction in sea ice thickness and extent, which is altering the distribution and abundances of keystone wildlife. Fundamental ecological knowledge from Digges Sound is pertinent to understand the historical connection of seabirds to the landscape as well as the unintended effects of climate change on coastal ecosystems and seabird nutrient subsidies in the Arctic.

33-O   Seasonal dynamics of high Arctic thaw ponds in a changing climate and consequences for greenhouse emissions.   *Isabelle Laurion* [1] *- Sally MacIntyre* [2] *- Alicia Cortes* [2]

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Small ponds associated with permafrost thawing in the Arctic are abundant yet overlooked ecosystems with a high potential to significantly contribute to the global carbon cycle. For example, trough ponds forming on top of ice wedges in continuous permafrost landscapes, presented relatively high dissolved greenhouse gas (GHG) concentrations in summer at the surface (up to 100 µM of CO_2 and 3 µM of CH_4) on Bylot Island Nunavut (73°N 80°W). Seasonal variations in surface gas concentrations and a proper estimation of the gas exchange coefficient (k) are needed to calculate diffusive flux, which is added to ebullition flux to evaluate the carbon footprint of these systems. Large uncertainties exist on diffusive flux because k is often computed from wind-based models but the fetch is small and boundary layer development uncertain. Trough ponds can be just a few square meters of area (< 50 m^2) and very shallow (< 1.5 m). The microtopography of ice wedge landscapes moderates the wind speed at the surface of ponds. For example, wind speeds measured ~10 cm above a trough surface and converted to 10 m following law of the wall scaling were 60% of those at an exposed station. The mixing regime also controls dissolved oxygen (DO) at the bottom of the water column, influencing GHG production and consumption rates as well as storage. For example, a trough pond was stably stratified from ice off with only a few mixing events which lasted two to three days before ice on. Its bottom water (1.1 m) had low DO concentrations in July and August (median 17%, range 0.8 - 83%), favouring the production of CH_4 and limiting its aerobic consumption. Oxygen saturation increased to 80% during two events induced by southerly winds, increased cloud cover and low relative humidity. The mixing was caused by net heat loss and persisted for its duration. Brief periods of mixing and low k imply small diffusive losses and storage of GHG. Stratification will also influence bottom sediment temperature during the open-water season, which was shown to control methane production and ebullition. The temperature of surface sediment (ca. first 5 cm) of a trough pond at its deepest point was on average only 2.2°C (max 5.5°C) during the "open-water season" (in our case when bottom sediments were above zero; bottom water avg 3.1°C), possibly explaining the relatively low ebullition rates observed at these sites. We aim to provide better estimates of turbulence and its drivers in shallow thaw ponds in order to strengthen diffusive flux estimations. We also aim to model future limnological conditions critical to microbial processes and GHG emissions under different climate scenarios. The areal extent of these ecosystems is increasing in the continuous permafrost area where a significant pool of carbon has been stored for millennia and is now mobilised through thawing.

33-O Lake morphometry and occurrence sticklebacks are the main drivers of size and age structure of arctic charr (*Salvelinus alpinus*) in west Greenland lakes. *Ignasi Arranz [1] - Lluís Benejam [1] - Sandra Brucet [1] - Frank Landkildehus [2] - Torben L. Lauridsen [2] - Thomas A. Davidson [2] - Nestor Mazzeo [3] - Ivan Gonzales-Bergonzoni [4] - Nicolas Vidal [2] - Korhan Özkan [2] - Irene Gallego [5] - Juliane Weschnewski [2] - Rosemberg Menezes [6] - Erik Jeppesen [2]*

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Greenland lakes are suitable model systems for evaluating fish population structure because of their relatively low species diversity and simple food web structure. Arctic charr (*Salvelinus alpinus*) mostly occur in these low-density systems, co-occurring with three-spined sticklebacks (*Gasterosteus aculeatus*). We aim at exploring the size and age structure of populations of Arctic charr across 17 West Greenland lakes, by also accounting for the effect of anadromy (i.e. migration of fish, from salt water to freshwater) and the presence of dwarf individuals of charr. The lakes hosted either a solitary population of Arctic charr or co-occurring charr and three-spined sticklebacks. Hence, these arctic systems provided a unique opportunity to study the influence of sticklebacks on the fish condition and habitat distribution of charr populations. Furthermore, as the lakes covered a wide range of areas and depths, we also searched for possible morphometric effects on two sympatric morphotypes of Arctic charr. The trophic niche use of sticklebacks and lake morphometry as well as the effects of intraspecific interactions with anadromous and dwarfs charrs may become the most important causes to regulate the population structure of Arctic charr in Greenland lakes. Finally, we will also discuss the implications of the changes in charr population structure in the context of the climate warming.

33-O Limnology of Ward Hunt Lake: a sentinel of environmental change in the Canadian High Arctic.
Warwick Vincent, Paschale Bégin

Centre for Northern Studies (CEN) & Dept De Biologie, Laval University, Quebec City, Canada

General circulation models predict that the most pronounced changes in global climate will be at the highest latitudes of the northern hemisphere, and far northern lakes are therefore well situated to be indicators of global change. Ward Hunt Lake (WHL) lies at the northern tip of the Canadian Arctic Archipelago (lat. 83°N). As in Antarctica, this ultra-oligotrophic lake (chlorophyll *a* concentrations less than 0.5 mg m^3) experiences a polar desert climate with a yearly average air temperature of -17°C and precipitation around 150 mm, and extreme seasonal variations in solar radiation, from continuous winter darkness to continuous light in summer. In the past, WHL has been covered by perennial ice up to 4.3 m thick, however complete loss of ice cover was recorded in 2011 and 2012, and we measured 2 m of summer ice cover in 2014 and 2015. The lake is inversely stratified beneath the ice, with bottom waters that warm to 5°C, and vertical gradients in conductivity and oxygen. Like many Antarctic lakes, WHL lacks crustacean zooplankton as well as fish, despite its proximity to Ellesmere Island and an outlet to the sea, and it has sparse populations of three rotifer species: *Rhinoglena frontalis*, *Keratella hiemalis* and *Polyarthra dolichoptera*. Our survey of the lake by underwater video camera revealed a luxuriant community of cyanobacterial mats (dominated by oscillatorian taxa) and mosses at the deepest site (10 m); underwater irradiance at this depth with 2 m of summer ice-cover was 0.5-1% of surface above-ice values. The inshore benthic communities contained larval chironomids which in their adult stage appear to migrate up through the candle ice of the lake. The summer phytoplankton of WHL was dominated by picocyanobacteria and phytoflagellates, as is often found in Antarctica; however the protist assemblage was strikingly different, with dominance by chrysophyte genera such as *Dinobryon* and *Kephyrion*, and several dinoflagellate taxa. Water column profiles showed strong differences towards the edge of the lake, with distinct limnological properties in the moat region. This horizontal structure in summer will be lost with ongoing climate change, and will result in an increased heat, momentum, nutrient, gas and biotic exchange between the littoral and pelagic zones of this sentinel High Arctic ecosystem.

33-O A winter perspective on arctic lakes ecology – examples from Svalbard and Greenland. *Kirsten Seestern Christoffersen*

Freshwater Biological Laboratory, University of Copenhagen, Copenhagen, Denmark

While studies of Arctic winter limnology are few, the understanding of seasonally frozen lakes has grown in recent years. Challenging environmental conditions such as low light penetration, cold temperatures and isolation from terrestrial and atmospheric environments poses restrictions on rates of primary and secondary production. Recent studies in lakes in Svalbard and Greenland have found that winter conditions are more important than previously considered because there are active pelagic and benthic populations and therefore active food webs. Ambient light and temperature conditions during winter result in inverse stratification in most Arctic lakes with warmer waters at the bottom and colder waters near the surface. This thermal regime is controlled by cold atmospheric temperatures cooling the surface waters and stored heat in the sediment warming the bottom layer. The chemical environment can change dramatically from summer to winter due to the effects of cryo-concentration during the development of lake ice. In relatively shallow lakes, where the under-ice volume: ice volume is small, cryo-concentration can have significant effects. Fex.Tenndammen in Svalbard has a mean depth of 1.5 m and an ice thickness of 1.0 m in late February. Chlorophyll is detectable and healthy zooplankton is present. When sampling in February. These and similar results illustrate that the winter period in Arctic lakes can nog be neglected and may become even more important as climate changes proceed.

33-O Stable isotopes and digital elevation models to study nutrient inputs and hydro-ecology of high-Arctic lakes. *Edoardo Calizza[1] , David Rossi [2], Maria Letizia Costantini [1], Giulio Careddu [1], Vittorio Pasquali [3], Loreto Rossi [1]*

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High-Arctic lakes represent hotspots of biodiversity and productivity in Arctic tundra. Ice cover, run-off from the watershed, aquatic and terrestrial primary productivity, guano deposition from birds control nutrient inputs in these water bodies. All these factors are expected to be significantly affected by climate change. Quantifying these controls is a key first step to understand what combination of factors underlies the biological productivity in Arctic lakes and will drive their ecological response to environmental changes. By mean of Digital Elevation Models and C (δ^{13}C) and N (δ^{15}N) isotopic analysis in sediments, vegetation, plankton and a macroinvertebrate species (*Lepidurus arcticus* Pallas 1973), we propose an integrated approach for the analysis of: (i) nutrient inputs in seven high-Arctic lakes (North Spitsbergen, Svalbard); (ii) the role of catchment hydro-geomorphology, position in the landscape, and birds presence in determining inter-lake differences in the isotopic composition of aquatic biomasses; (iii) effects of diverse nutrient inputs on the isotopic niche of *L. arcticus*.

The isotopic niche of *L. aricticus* reflected differences in isotopic composition of resources between lakes, suggesting a strong bottom-up effect of hydro-ecology on nutrients assimilated, trophic position and niche width of this species, whose trophic preferences were strongly size-dependent. Isotopic composition of sediments and vegetation varied between lakes, being mainly affected by catchment hydro-morphology and guano deposition from birds in "inland" and coastal lakes respectively. Differences in isotopic composition were associated with differences in nutrient concentration in sediments, relating nutrients' origin with ecosystem stoichiometry. Isotopic signatures were similar between samples within each lake, posing δ^{13}C and δ^{15}N as precise tracers for studies on the effect of climate change on biogeochemical cycles in Arctic tundra. In addition, integrated data allowed the modelling of changes in ecosystem stoichiometry associated with future environmental variations expected for high-Arctic lakes, including increasing terrestrial inputs or primary productivity for inland lakes and increasing birds colonization for coastal ones. The presented approach proved to be an effective research pathway to understanding the link between hydro-geomorphology and ecology across lakes and for the identification of factors controlling nutrient inputs within each water body. Accordingly, we believe such approach to have the potential to provide mechanistic understanding of both biological productivity at lower latitudes and responses of temperate systems to future climate changes.

33-P   Decode the sentinels' report: how watersheds influence the phytoplankton's signal in alpine lakes.   *Coralie Jacquemin* [1] - *Céline Bertrand* [1] - *Benjamin Oursel* [1] - *Stéphane Mounier* [2] - *Evelyne Franquet* [1] - *Laurent Cavalli* [1]

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Alpine lakes can quickly and significantly respond to global changes. Their use as sentinels of these changes is recognized by scientific community. Characterized by some similarities (e.g., small sizes, extreme environmental conditions, simplified food webs), these lakes also differed in many ways (e.g., altitude, location, morphology, characteristics of the watershed). The effects of a given change may vary depending on the lakes, but all responses' patterns are still poorly understood. Phytoplankton species are sensitive to any environmental change and can be used as a good bio-indicator of lakes functioning. Different ecological successions are known based on trophic and climate conditions in lowland lakes, but algal structure can sometimes be unexpected in high altitude ones. This study aims to better evaluate the watersheds influence on phytoplankton communities in alpine lakes. The amount of organic matter and nutrients intercepted by lakes depends on watershed characteristics (area, ground cover) and uses. Nutrients can widely constrain algal communities in these ecosystems. We hypothesize that high catchment area provides more allochthonous inputs to the lake and induces a longer algal succession with a higher primary productivity through the thawing phase. In the Ecrins and Mercantour National Parks (France), two groups of shallow lakes with similar characteristics (e.g., morphologies, tributaries, fishes and macrophytes presence) were sampled four times in summer 2015: two with small, mineral watershed, and two with large vegetated catchment area with pastoral activity. In lakes, the nature and origin of dissolved organic matter were determined by 3D fluorescence spectroscopy. The origin of nutrients transferred into food web was determined by isotopic analyzes. Algal communities were studied based on species identification, biomass estimation and functional group classifications. Results show that phytoplankton biomass and species diversity are significantly higher for lakes characterized by a large catchment area. Species show different functional traits depending on the size of the watershed. Small size species dominate communities in lakes located in small watershed whereas larger colonial species dominate in lakes located in large watershed. Global warming will have multiple effects on high altitude lakes (e.g., water temperature, stratification processes, ice cover). Through a better understanding of their phytoplankton structure, this work opens new prospects in identifying potential responses of these ecosystems to global changes.

33-P   Resilience of alpine lakes invertebrates after the eradication of introduced brook trout *Salvelinus fontinalis.*   *Rocco Tiberti* [1] - *Stefano Brighenti* [1] - *Rocco Iacobuzio* [2] - *Matteo Rolla* [3] - *Achaz von Hardenberg* [1] - *Bruno Bassano* [1]

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Alien fish have been introduced into once fishless mountain lakes worldwide, seriously affecting native biota. In the Gran Paradiso National Park (GPNP, Western Italian Alps), the brook trout (*Salvelinus fontinalis*) was introduced in several alpine lakes, where it dramatically affected the entire ecosystems, thus leading the GPNP to undertake an eradication campaign,   within the EU financed LIFE+ BIOAQUAE (Biodiversity Improvement of Aquatic Alpine Ecosystems) project. The eradication started in June 2013 in three small lakes (depth range: 3-7.4 m) and one large lake (depth: 22.1 m). Intensive gill netting and electrofishing have been used as non-invasive eradication techniques, without lethal effects on native species, potentially including taxa deserving special attention under a conservation point of view. The effects of the eradication are being monitored along with the eradication campaign, comparing the lakes subject of the eradication project with a set of control lakes (both naturally fishless lakes and lakes still containing brook trout) as a reference to quantify the ecosystem resilience using littoral macroinvertebrates and pelagic zooplankton as indicators of the ecological resilience. At its fourth field campaign (June-September 2013-2016) the removal of introduced fish enabled the recovery of many invertebrate taxa. In particular many benthonic and nektonic macroinvertebrates (Plecoptera, Etreroptera, Coleoptera, Tricoptera, Acarina), which were previously absent, rapidly recolonized the lakes, while the large bodied zooplankton crustacean *Daphnia longispina* (which was under a strong predatory selection) has

returned to dominate the zooplankton community of the lakes. These results show the high resilience potential of the invertebrate fauna of alpine lakes after fish eradication and encourage management and conservation authorities to undertake new eradication projects.

34. ALIEN SPECIES ECOLOGICAL IMPACTS: FROM GENOMICS TO MACROECOLOGY

34-O Open access electronic journals: an effective online tool for support of expert networking and e-science in the area of biological invasions.   *Vadim Panov* [1] *- Frances Lucy* [2]

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Invasive alien species (IAS) are considered to be one of the main direct drivers of biodiversity loss at the global level. The international community has responded to the growing challenge posed by IAS with the development of several related legal instruments, including the new EU Invasive Species Regulation and relevant provisions within the Convention on Biological Diversity. The provision of high quality information on alien species ecology, distribution, pathways of introduction, impacts, and effective management strategies is imperative for the effective implementation of IAS-related legislative instruments and management plans. The scientific community plays a critical role in generating reliable IAS-related information, and sustainable mechanisms are needed to transfer this information to diverse decision-making platforms, involving policy makers, environmental managers, and other interested parties. In this regard, the application of e-Science principles to biological invasion research, by developing user-friendly online tools, may help embed innovative communication methods and information management tools thereby benefitting a broad scientific community.

Since its establishment in 1998, the SIL Working Group on Aquatic Invasive Species (SIL WG AIS), focuses on development of innovative instruments for facilitation of expert networking in the area of biological invasions and support of IAS-related open information systems and networks. As an initiative of SIL WG AIS, in 2001, the first online pan-European information system on invasive species (REABIC, http://www.reabic.net) and virtual European Research Network on Aquatic Invasive Species (ERNAIS) were developed. In 2006, its first international open access electronic journal, *Aquatic Invasions*, was established by SIL WG AIS as an innovative online instrument for support of ERNAIS expert communication, while also serving as cost-effective early warning tool on aquatic invasive species, incorporated within the REABIC information system. Currently *Aquatic Invasions* is an internationally recognised publication platform for academic research in the area of biological invasions, delivering excellent open knowledge on impacts of aquatic IAS to society.

Incorporation of thematic open-access journals in the REABIC information system (REABIC's other IAS e-journals are *BioInvasions Records* and *Management of Biological Invasions,* http://www.reabic.net/journals/) represents a highly original e-Science related concept. These journals represent a novel information technology for support of open information systems and databases, with timely data on records of IAS while providing information, essential for development of relevant management options on global, regional and national levels. Also, open access publishing effectively supports expert networking and citizen science in the area of biological invasions, by raising awareness on this global environmental issue.

34-O   European Alien Species Information Network (EASIN): supporting scientific research & European policies.   *Konstantinos Tsiamis, Ana Cristina Cardoso, Eugenio Gervasini*

European Commission, Joint Research Centre, Institute for Environment and Sustainability, European Commission, Ispra, Italy

E-Science approach is crucial to address the growing threat of alien species (AS), allowing a better understanding of their success and contributing to a more appropriate management. To this end, the European Alien Species Information Network (EASIN) was launched in 2012 by the European Commission. EASIN is an online platform of interoperable web services aiming at facilitating the exploration of existing information on AS from distributed sources, and to assist the implementation of European policies on AS. EASIN has been identified as the supporting tool for the implementation of the recently published EU Regulation 1143/2014 on Invasive Alien Species (IAS). The core of the system, namely the EASIN Catalogue, includes more than 14.000 AS in Europe, including all kinds of taxa and habitats. For each taxon listed, EASIN gathers information on taxonomy, year and country of first introduction in Europe, habitat, pathways, impact, synonyms and common names. In addition, EASIN aggregates, integrates and harmonizes spatial occurrences of alien species in Europe, available from a partnership of global and European databases and literature: GBIF, GISIN, REABIC,

ELNAIS, CIESM, HCMR-EEA, MEDMIS, EASIN-Lit. To guarantee the quality of the EASIN data, an Editorial Board, composed of experts on different taxonomic groups and habitats, has been appointed and is contributing to the continuous update and review of the EASIN Catalogue by means of on-line discussions via a forum-like platform. All the information gathered in the EASIN system is publicly available through a widget framework, providing easy to use and flexible web tools for tailored searching, analyzing and mapping, greatly aiding scientists and policy makers in obtaining high quality information. These web tools follow internationally recognized standards and protocols, and can be utilized freely, while ownership of the data remains within its source, which is properly cited and linked in the EASIN geodatabase. The EASIN datasets have been used for pan-European or regional assessments of pathways and gateways of alien invasions, pinpointing the major importance of shipping and the Suez Canal for the marine introductions, and aquaculture, pet/aquarium trade and stocking activities for the freshwater AS, contributing thus towards the fulfilment of the related targets of the Convention on Biological Diversity and of European policies. Moreover, through the EASIN datasets and tools, a pan-European review on highly invasive marine alien species has been performed, highlighting 87 species with a high impact on ecosystem services (mainly food provision) and biodiversity. Finally, an index is under development for mapping cumulative impacts of marine IAS, allowing the identification of hotspots of highly impacted areas and prioritization of sites, crucial for management actions.

34-O   Non-native species in Ialian freshwater habitats: a macroecological assessment of invasion drivers.

Paolo Colangelo [1] - Diego Fontaneto [1] - Aldo Marchetto [1] - Alessandro Ludovisi [2] - Alberto Basset [3] - Luca Bartolozzi [4] - Isabella Bertani [5] - Alessandro Campanaro [6] - Antonella Cattaneo [7] - Fabio Cianferoni [4] - Giuseppe Corriero [8] - Gentile Francesco Ficetola [9] - Cataldo Pierri [8] - Gianpaolo Rossetti [5] - Angela Boggero [1]

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The relative role of propagule pressure, abiotic and biotic variables as determinants of non-native species occurrence differs among studies, hindering the synthesis of emergent patterns in invasion ecology and preventing generalisation for conservation actions. In order to produce a broad and general assessment of the occurrence of alien species in aquatic habitats, we proposed a macroecological approach to assess the drivers of occurrence of alien species in all biota (microorganisms, plants and animals) across several natural habitats in freshwater ecosystems in Italy, and we generalised the results of the analysis to provide a risk map of the occurrence of alien species.
We determined that abiotic climatic variables were good predictors of alien species occurrence. Indeed, these variables, together with propagule pressure, expressed as the proximity to major inhabited areas, and differences in the receiving community, expressed as the native species richness, played a crucial role in determining the number of alien species. Furthermore, we found evidence of an influence of body size in determining the occurrence of the non-native species. By using the predictions of our model, we addressed the probability of the occurrence of alien species in freshwater habitats across the whole country and highlighted areas at higher risk.

34-O   Contribution of non-native species to fish communities in 1940 european lakes: geographical distribution, predictors of occurrence, and proportions in community abundance and biomass.

Thomas Mehner [1] - Carolina Trochine [2] - Christine Argillier [3] - Ignasi Arranz [4] - Meryem Beklioglu [5] - Lluís Benejam [4] - Teresa Ferreira [6] - Trygve Hesthagen [7] - Kerstin Holmgren [8] - Erik Jeppesen [9] - Fiona Kelly [10] - Teet Krause [11] - Samo Podgornik [12] - Martti Rask [13] - Pietro Volta [14] - Ian Winfield [15] - Sandra Brucet [4]

Leibniz-institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany [1] - Universidad De Comahue, Bariloche, Argentina [2] - National Research Institute of Science And Technology - IRSTEA, Aix-en-provence, France [3] - University of

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The invasion of non-native species is considered one of the major threats for biodiversity worldwide. Freshwater ecosystems are still relatively poorly studied in this context, and there is no systematic overview on non-native fish species in European lakes. We took advantage of the important sampling effort and data collection on fish communities following the implementation of the European Water Framework Directive, and compiled information on non-native fish species in 1940 lakes and reservoirs from 13 European countries plus Turkey. Non-native species occurred only in 297 lakes or reservoirs (15.3% of total). The highest proportions of non-natives (>80% of species richness) were found in 38 Irish lakes and 5 reservoirs of Spain and Portugal. The proportions of non-natives in overall lake species richness correlated closely with proportions of non-natives in approximations of total fish abundance and biomass. This strong correlation suggests that non-natives rarely came to community dominance in lakes, which are characterized by a high richness of native species. The dominant predictors of non-native proportions were temperature, precipitation and lake spatial dimensions (area and depth), whereas total phosphorus (TP) concentration was not a significant predictor in a subset of lakes for which TP data were available. We conclude that many European lakes are still relatively unimpacted by fish species invasions, and that the changes observed in dominance structure of fish communities after invasions are still modest.

34-O   Is there a latitudinal gradient of biotic resistance to plant invasion?   *Antonella Petruzzella, Elisabeth S. Bakker, Ellen van Donk*

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Invasive plants threaten native biodiversity, alter ecosystem structure and functioning and cause annual losses of millions of Dollars worldwide. There is an urgent need of greater understanding of general patterns and, mainly, mechanisms underlying the success of invasion. Biotic resistance or the role of species interactions in decreasing the success (i.e. establishment or performance) of invasive species has currently been invoked as an answer to the crucial question: why do not all introduced species become successful in their new range? Previous studies have demonstrated that the tropics harbor lower numbers of invasive species than at higher latitudes, which is true for nonnative groups of terrestrial mammals, birds and terrestrial plants. Following an opposite pattern, however, the latitudinal gradient of species diversity proposes that native species richness increases from the poles to the tropics. It has widely been assumed that biotic interactions, such as competition and herbivory, are stronger and more specialized in the tropics, which promoted further diversification and explains greater species richness compared to temperate zones. The strength of biotic interactions is believed to play an important role in the origin and maintenance of species diversity, as well as, resistance to invasion. Therefore, the question remains whether there is a latitudinal gradient of biotic resistance. We tested the hypothesis that biotic resistance to invasion in plant communities is stronger at low latitudes. Here, we present the results of a meta-analysis of plant invasion literature, including studies that experimentally manipulated any source of biotic resistance, such as competition or herbivory, in situ or mesocosms, across wetland, marine and terrestrial ecosystems.

34-O   Role of genetic identity and diversity in cyanobacteria invasion.   *Sarah Bolius [1] - Karoline Morling [2] - Claudia Wiedner [3] - Guntram Weithoff [1]*

Institute of Biochemistry and Biology - Ecology and Ecosystem Modelling, University of Potsdam, Potsdam, Germany [1] - Department of Lake Research, Helmholtz Centre for Environmental Research (UFZ), Magdeburg, Germany [2] - Department of Freshwater Conservation, Brandenburg University of Technology, Cottbus (BTU C-s), Cottbus, Germany [3]

The invasion of species can have a severe impact on the environment and economy. Compared to terrestrial plants or animals, relatively little is known about the mechanisms of the invasion success of aquatic microorganisms. As microbes often have a high reproduction rate and are difficult to survey on the species level - it is important to learn more about

the factors (susceptibility of the resident community, diversity, productivity) that are relevant for invasion events. We tested how the individual characteristics of differing isolates, their genetic diversity and the coexisting community effect the invasion success by using the invasive cyanobacterium *Cylindrospermopsis raciborskii*. We used microcosms with a multi-species resident phytoplankton community and a gradient of cyanobacterial diversity. The ten different isolates of *C. raciborskii* originated from different lakes in northeast Germany. We also compared the effect of different sized rotiferan consumers (*Brachionus calyciflorus*; *Cephalodella sp.*) and different rotifer abundances. Our results suggest that the invasion success of cyanobacteria depends on the predator density. A high concentration of herbivores, which is capable of feeding on filamentous cyanobacteria, can have a negative effect on the invasibility. As the isolates vary in individual traits (e.g. growth rate) we could also show that these specific characteristics lead to different levels of invasibility and are therefore an important factor for the invasion success. In addition, results revealed that the resident phytoplankton species responded differently to the presence of *C. raciborskii*.

34-O   Whole food web restructuring by an invasive ecosystem disruptive algal bloom species.   *Dave Hambright* [1] - *Dave Caron* [2] - *Adriane Jones* [3] - *Brenda Allison Witt* [4] - *Richard Zamor* [5]

Department of Biology; Environmental Studies, University of Oklahoma, Norman, USA [1] *- Biological Sciences, University of Southern California, Los Angeles, USA* [2] *- Biological Sciences, Saint Mount Mary's Univesity, Los Angeles, USA* [3] *- Environmental Science, Redlands Community College, El Reno, USA* [4] *- Ecosystems & Lake Management, Grand River Dam Authority, Langley, USA* [5]

Ecosystem disruptive algal blooms (EDABs) were first described as blooms of toxic or unpalatable algal species that disrupted energy flow and nutrient recycling by reducing grazing rates of planktonic and benthic herbivores. Inland water blooms of the toxigenic marine haptophyte, *Prymnesium parvum*, have been categorized as EDABs primarily because they can cause massive fish kills during blooms, although secondarily, some research has noted other effects, particularly on zooplankton feeding and survival. Here we present results of a long-term field and laboratory research program in which we have documented major shifts in pelagic communities during *P. parvum* blooms including dramatic restructuring of bacterial, protistan, zooplankton, and fish assemblages. Additionally, anecdotal evidence indicates changes in the dynamics of predation and fishing habits by bird and human populations, respectively. Thus *P. parvum*, particularly in inland water bodies, redefines and expands the concept of an EDAB to truly include the entire ecosystem. Although evidence is limited at present, we suspect that such major changes in community composition and dynamics across the entire food web also will have profound ecosystem-wide functional repercussions.

34-O   High daily consumption rates of the invasive *Dikerogammarus villosus* in large central European rivers – one of the keys to its success?   *Susanne Worischka* [1] - *Luise Richter* [2] - *Claudia Hellmann* [1] - *Carola Winkelmann* [1]

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Invasive species are assumed to affect native communities by replacing competitors, overexploiting prey species or altering ecosystem structure. One example is the Ponto-Caspian amphipod *Dikerogammarus villosus* whose invasion in Central European rivers is widely considered as a main cause for the decline of native benthic macroinvertebrates. However, these assumptions are seldom tested because population-level effects of invasive species are difficult to investigate and large-scale observations often lack statistical power. We performed an outdoor flow-through channel experiment manipulating the density of *D. villosus* and analyzing its effects on the benthic community of the Rivers Elbe and Rhine. For this purpose, we exposed substratum-filled baskets inhabited by benthic invertebrates for 6-8 weeks to three different *D. villosus* densities in three mesocosm channels each.
A prerequisite for causal analysis of both direct (predation) and indirect (competition) effects on the benthic community is the quantification of the invader's food consumption. Daily rations of *D. villosus* were estimated in situ during 24-h gut content surveys in the mesocosms. Gut evacuation rates for correction were measured in the laboratory for different food sources and under realistic conditions, i.e. constant feeding. The 24-h surveys were conducted in spring (Elbe and Rhine) and in autumn (Rhine). Additionally, periphyton grazing and leaf litter decomposition by the benthic community in the mesocosms at different *D. villosus* densities were quantified.

D. villosus showed exceptionally high food consumption rates which may be attributed mainly to its high gut evacuation rates as well for leaf litter as for animal prey. The periphyton biomass in the mesocosms was only partly correlated to *D. villosus* density whereas the leaf litter decomposition rates suggest that *D. villosus* was an effective shredder. In connection with stable isotope analyses indicating a relatively low trophic level for *D. villosus* in the river food webs, we conclude from these results that *D. villosus* is rather a superior competitor than a predator in the benthic food webs of the analyzed rivers, and its effects are mainly indirect. High consumption rates together with an opportunistic feeding behaviour probably promote the success of this invader.

34-O   Competition between the introduced signal crayfish (*Pacifastacus leniusculus*) and native fishes.   *Iván Vedia*

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Competitive interactions between fish and crayfish have two main focuses, food and shelter. In particular, we study the competition between the signal crayfish Pacifastacus leniusculus (Dana, 1825), one of the most successful crayfish invaders in Europe, and native fishes. This study is located in the Mediterranean rivers of the province of Navarra (Ebro Basin, Spain). The ethology and interspecific behavioural interactions of this crustacean on fish species are widely reported in experimental aquaria. However, few studies analyses these interactions in natural settings. The goals of this study were to analyse the behaviour of P. leniusculus and to study its interactions with native fishes such as the stone loach (Barbatula quignardi), trout (Salmo trutta) or minnow (Phoxinus bigerri). Furthermore, we evaluate the trophic competition between this crayfish and the native fish species using both stomach content and stables isotopes of carbon and nitrogen. For the ethological study we used underwater video cameras modified for night vision and infrared focuses to illuminate without disturb the natural behavior of the animals. The main behaviors of 260 individuals of signal crayfish and its interactions with native fishes were studied. Competition for habitat between signal crayfish and fishes was higher with benthic fish species. For the study of stomach content and the analysis of stable isotopes, a total of 85 individuals of signal crayfish were analyzed. The abdominal muscle of the same specimens was taken to measure the stable isotope ratios of crayfish. The trophic overlap between the crayfish and the native fishes was calculated in R with the Stable Isotope Bayesian Ellipses (SIBER). A similar diet and isotopic niche overlap was observed between the introduced crayfish and the native fishes, suggesting a trophic competition between the species when resources are limiting. This research was funded by the Research Program of the University of Navarra (PIUNA 2014-16).

34-O   *Elodea canadensis* (Michx.) in polish lakes: a non-aggressive contribution to native flora.
Agnieszka Kolada

Institute of Environmental Protection - National Research Institute, Warsaw, Poland

The distribution, abundance and habitat requirements of *Elodea canadensis* (EC) in 447 Polish lowland lakes surveyed during the years 2005–2013 were analysed. The changes in spatial distribution of EC in lakes throughout the country were explored with the use of GIS tools. The most frequently accompanying hydrophyte communities and the main environmental factors determining EC performance were explored using multivariate (detrended correspondence analysis) and comparative (Mann–Whitney U-test, paired sample t-test) statistics. The EC phytocoenoses were identified in approximately 30% of lakes surveyed each year and this proportion was stable throughout the analysed period. The area occupied by EC ranged from 2.3 to 5.5% of the total vegetated area per year, on average, with a maximum of 37.8%. The habitat preferences of EC shifted toward larger and deeper lakes located at higher altitudes, with better water quality and in better ecological status based on macrophytes compared to lakes not invaded. The EC was most frequently accompanied with the phytocoenoses of submerged angiosperms typical of meso-eutrophy and more tolerant species of stoneworts. A comparison between subsequent years, as well as between two sub-periods (2005–2009 and 2010–2013) revealed a lack of increase of EC mean abundance. Likewise, no evidence of EC effects on the native flora, its richness and its diversity nor on the ecological status of lakes in the analysed period were found. In the analysed period, EC did not demonstrate invasive character in Polish lakes.

34-O Interspecific and intraspecific isotopic niche variation of invasive mysids in Lake Constance.

Elizabeth Yohannes, Karl-Otto Rothhaupt

Limnological Institute, University of Konstanz, Konstanz, Germany)

Limnomysis benedeni and *Katamysis warpachowskyi* are highly invasive species originating from the Ponto-Caspian region of Eastern Europe and were first observed in Lake Constance in 2006 and 2009, respectively. In a previous study, using stable isotopes carbon (δ^{13}C), nitrogen (δ^{15}N) and sulphur (δ^{34}S) signatures, we provided evidence that both species maintain differentiated feeding niches by feeding on distinct components of the available food resources (predominantly seston by *L. benedeni* and periphyton by *K. warpachowskyi*). This pattern was consistently found at several sampling sites on Lake Constance and the river Rhine. One conspicuous outcome of the previous study was the high δ^{13}C niche variability of the mysids, especially of *L. benedeni*. This finding prompted us to study the isotopic niches in more detail and to look for intraspecific patterns with age (juvenile and adult), sex (male and female), reproductive state (gravid and non-gravid) and seasonal cohort (large spring shrimps and small summer shrimps). We applied two approaches for isotopic niche calculations: standard Bayesian ellipses and convex hull; and conventional analysis of variances. Moreover, we measured the relative contribution of seston and periphyton to the diet of different mysid groups using Bayesian mixing models. Our results show that body size differed significantly between winter and summer generations in *L. benedeni*. The two mysid species differed in their isotopic niche width and partition resources by feeding on distinct components of the available food resources (predominantly seston by *L. benedeni* and periphyton by *K. warpachowskyi*). Overall, smaller δ^{13}C, δ^{15}N and δ^{34}S niche width was found for *Katamysis.* Gravid females of both species had largest δ^{15}N niche width, and non-gravid female held the smallest δ^{15}N after male *Katamysis.* In conclusion, interspecific and intraspecific feeding niche differentiation might facilitate the coexistence of invasive mysids in their 'new' environment by minimizing direct resource competition. On the other hand, such a concerted resource use pattern may aggravate the impacts that invasive mysids have on affected communities.

34-P   Alien species among Chironomids: a new topic on which direct our interest.   *Angela Boggero*

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Non-indigenous alien species are considered one of the main threats to biodiversity all over the world, and their negative ecological and economic effects have been extensively documented. Usually, researches on alien and invasive species in aquatic ecosystems were mainly directed towards the study of economically important and larger species, whereas small taxa or groups have rarely been considered. Non-biting midges (Chironomids), inhabiting in relatively large number different type of habitats (mainly freshwaters, but also brackish and marine waters, as well as terrestrial lands) are well studied under the morphological, ecological, physiological and molecular point of view and often dominate the aquatic insect community. Unfortunately, very few studies concerning their alien character has been carried out so far. Following the general definition of alien: deliberately or inadvertently introduced in an area by human activities and with a distribution not including the territory under study before the discovery of the New World by Columbus in 1492, we are to date, not able to say if they are present on the national territory and how many they are. Their natural distribution is difficult to determine because the larvae are difficult to identify at species level and the adults are short-living forms. In addition, in Italy, many are the habitats not adequately monitored for their presence, such as lakes in insular Italy or high altitude streams and lakes.

We know their potential impact as nuisance pest during swarms, as vectors of pathogenic species or of allergy, as threat to agriculture in newly flooded rice-fields, or as competitors with native species. Among them, examples of alien species around the world are present, but very few is known about Italy. Usually, species captured and described outside the West Palearctic are potential candidates to be considered alien, like the Afrotropical *Polypedilum nubifer* (Skuse 1889), recently found in Italy.

Detailed studies on chironomids have to be performed to find out alien species presence and their spread, because chironomids are key organisms in aquatic ecosystems, so could represent a puzzle and a potential problem in the near future.

34-P Zebra mussel and killer shrimp interactions in mesocosm conditions.   *Matteo Rolla* [1] *- Teja Muha, Marta Rodriguez Rey, Sonia Sofia Consuegra del Olmo, Carlos Garcia de Leaniz*

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There are nearly 2,000 non-native species established in the UK, most of which are terrestrial (c. 1,800), with smaller numbers in the marine and freshwater environments (c. 80 in each); the number of new arrivals is also increasing, with 10-12 new non-native species becoming established every year. A particular case of concern is the zebra mussel, *Dreissena polymorpha* (Pallas, 1771), a species responsible for huge ecological and economical damage in North America, and which is now increasing at an alarming rate in the UK. Interactions between zebra mussel and the killer shrimp, *Dikerogammarus villosus* (Sowinsky, 1894), another freshwater invasive species that recently arrived in UK, were studied under laboratory and mesocosm conditions. The potential for synergistic impacts between these two species warrants further research, as the presence of one of these invasive species may facilitate the dispersal and settlement of the other.
The Marie Skłodowska-Curie ITN Aquainvad-ED project is financing 8 PhD students focusing their research on the problems posed by aquatic invasive species (AIS), including those caused by the zebra mussel and the killer shrimp. At Swansea University, we are studying the relationship between zebra mussel and killer shrimp, in relation to 1 habitat engineering, 2 chemical attraction and 3 activity levels. This study will advance knowledge on potential synergistic impacts between AIS and inform management and mitigation programmes.

34-P Habitat use and population structure of the invasive red swamp crayfish (*Procambarus clarkii*) in the natural reserve of the Lago di Candia (Italy).   *Roberta Donato* [1] *- Marta Rollandin* [1] *- Alessandra Pucci* [2] *- Alessio Ferrarese* [3] *- Livio Favaro* [1] *- Daniela Pessani* [1]

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The red swamp crayfish (*Procambarus clarkii*, Girard 1852) is considered the most invasive Non Indigenous Crayfish Species (NICS) in Italy, where it is responsible for the decline of native communities of flora and fauna. In 2010, the red swamp crayfish was observed for the first time also in the Lago di Candia (Northwestern Italy): a natural reserve protected by the Italian laws since 1995. The area is also considered a Site of Community Importance (SCI), according to the Habitats Directive and a Special Protection Area (SPA), according to the Birds Directive. The aim of this study is to describe the population structure and habitat use of the red swamp crayfish within the Natural Reserve. In order to reach this goal, we investigated the ecological, reproductive and feeding behavior of the species during seven weeks from July to October 2014. In particular, we evaluated the presence and distribution of *Procambarus clarkii* using 114 baited fishing traps in the lake and 40 baited fishing traps in an adjacent marsh area. All the sampling points were georeferenced and for each of them we registered several microhabitat parameters relative to the continuity of aquatic vegetation, typology of lake bottom, and bank alteration by human activities. We placed the fishing traps every Monday and we collected the crayfishes every 24 hours, from Tuesday to Friday, for a total of four sampling days per week. All the specimens collected were anesthetised and subsequently euthanized. For each crayfish, we determined the sex and measured the following morphometric parameters to be used to define the population structure: cephalothorax length, weight, number of chelae, presence of eggs. Morphological data were then analysed using the Fisat II software (FAO-ICLARM Stock Assessment Tools II). Finally, we analysed stomach contents for selected specimens (both sexes and different age classes) captured without the use of baited traps. This allowed us to describe the diet of the species in the study area and its potential implication for the indigenous flora and fauna. Our results confirm a stable presence of the red swamp crayfish in the Natural Reserve of the Lago di Candia, with an active reproductive population. Moreover, we found that the continuity of the aquatic vegetation and the bottom typology influence the distribution of the specimens within the lake. The analysis of the bathymetry also revealed that the species does not occur in water deeper than two meters. Finally, we observed that the crayfish causes mechanical damages to the vegetation and feeds on some aquatic plant of particular conservation interest, such as the Water caltrop (*Trapa natans*) and the Yellow Water-lily (*Nuphar lutea*). Overall, we recommend a long-term monitoring of the impact of the red swamp crayfish to the fragile ecosystem of the Lago di Candia. We also underline the need of reliable eradication measures to control the diffusion of this invasive crayfish species in Northern Italy.

34-P   Coexistence of *Sinonodonta woodiana* with native unionidae in the Odra River.   *Agnieszka Szlauer-Łukaszewska [1] - Wojciech Andrzejewski [2] - Henryk Gierszal [3] - Małgorzata Ożgo [4] - Maria Urbańska [5]*

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The Chinese pond mussel *Sinanodonta woodiana* (Lea, 1834) is a freshwater bivalve alien to Europe. The continuously growing number of new localities where *S. woodiana* has been discovered, as well as its biology and ecology, indicate that this species easily spreads in European freshwater habitats and it is currently considered to be a significant threat for native unionid mussels. In Poland *Sinanodonta woodiana* has been found in stagnant water bodies, mainly in fish ponds. In contrast to other European countries, in Poland there was so far lack of information about its presence in large rivers. In the lower Odra (Oder river) and Warta we determined the co-occurrence of *S. woodiana* with native species of Unionidae. This was possible thanks to the long lasting drought, which led to declines in water levels in most inland reservoirs. Samples were collected in autumn 2015 from groyne fields by square frames of 0.5 sq m.
On four selected sites we found 18 alive Chinese pond mussels. *S. woodiana's* shell length was from 38-118 mm. *S. woodiana* reached a low density - from 0.5 to 2.6 individuals / m^2 and coexisted with native species of Unionidae: *Anodonta anatina, Unio. tumidus, U. pictorum* and *Pseudanodonta complanata*. S. woodiana constituting from 1.85 to 6.1% of the unionid mussels present in the river. *A. anatina* and *U. tumidus* were more frequent than *S. woodiana,* constituted from 16,3-39% and 35-60,3% respectively.
The results proofed that Chinese pond mussels may quickly expand their range along the river, is able to settle a large lowland river and for many years coexisted with native species in the Odra without reaching significant abundance and biomass (*S woodiana's* biomass - 3,64 to 26,15%). The large river habitat is probably more optimal for native species of Unionidae. In this case the diversity of native species and their high density suggests that the presence of the small number of Chinese pond mussels do not seem to have an unequivocally negative effect on the native clam. The river-bed of the Odra, diversified habitats of the areas between groynes field, and numerous oxbow lakes provide favorable conditions for the occurrence of species with various ecological requirements making their long term co-occurrence possible.

34-P   The impact of alien vascular plants in the aquatic habitats of a mediterranean island: preliminary data and observations in Sicily.   *Angelo Troia [1] - Elisabetta Oddo [1] - Rosario Schicchi [2]*

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As is well known, invasive alien species pose a major global threat to the conservation of biodiversity, causing the extinction of native species and modifying ecosystem functions: this is true also for aquatic habitats, particularly susceptible to invasion due to usually high disturbance regimes and easy dispersal of propagules. The island of Sicily is one of the main hotspots of plant biodiversity, in the center of the Mediterranean basin; it hosts different types of freshwater habitats, both lentic (coastal wetlands, saltworks, temporary ponds, lakes, reservoirs) and lotic (springs, streams, permanent and seasonal rivers).
As a first step of our analysis of the effects of the alien vascular plant species on the aquatic habitats of the island, an updated list of these alien species reported for the Sicilian aquatic habitats has been compiled, including archeophytes (to be considered a minor threat because of the long amount of time since their introduction) and neophytes; we used the term "aquatic plants" in its broadest sense to include all plants that occur in permanently or seasonally wet environments, distinguishing emergent, submergent and floating species. As regards floating species, in the last years new alien species, such as *Lemna minor* L., and new populations of already reported alien species, such as *Eichhornia crassipes* (Mart.) Solms, have been reported. A similar trend has been verified also for the emergent species (e.g. the new alien species *Typha laxmannii* Lepech.). From available data it is clear that additional research on the field is needed. We focused our attention on wetlands in protected areas; in fact they usually are delicate areas hosting rare species and/or ecosystems. The study of functional traits (such as gas exchange, leaf area index, leaf nutrient and chlorophyll concentrations, etc.) of invasive alien species can aid in predicting their impact on the evolution of natural wetlands.

We specifically studied the following sites: the coastal wetlands in the Petrosino area and the saltworks of Trapani and Paceco (both of them Ramsar sites, in the western part of Sicily), and the small mountain lakes in the Nebrodi Park, above 1200 m a.s.l., in the north-eastern part of the island. Here we assessed the impact of alien vascular plants on wild habitats, considering their ways of dispersal and colonization in the different geographic and anthropic contexts.

34-P   Native and non-native aquatic plants of South America: comparing and integrating GBIF records with literature data.   _Vanessa Lozano[1], Giuseppe Brundu[1], Cástor Guisande [2]_

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The Global Biodiversity Information Facility (GBIF) is at the moment one of the largest and most widely used biodiversity database. Nevertheless, there are still some limitations, e.g. in terms of plant species status (native vs. non native) and geographic resolution of records. The digitization of records reflect an effort to assemble all existing data, as well as to provide resources that can be used to monitoring biodiversity and assist nature conservation. At the same time, it is well known that alien plant invasions in inland freshwaters can alter community structure, ecosystem functions and services with significant negative impacts on biodiversity and human activities. The present research aims to assess if the GBIF database has a geospatial homogeneous information for native and non-native aquatic plant species for South America and whether or not it does provide additional information in comparison to literature (floras, checklists and other papers). To this aim, from a regional database of South America holding information on more than 1,000 aquatic species, we selected a set of 200 native and non-native aquatic species. Synonyms used in the literature were handled in accordance to The Plant List portal to ensure that all records were assigned to an accepted valid name in agreement with GBIF taxonomic treatment. These 200 species included a sub-set of 40 alien species previous evaluated with the USAqWRA scheme (US Aquatic Weed Risk Assessment). Species with non reliable identification, duplicates of the same collection, records without georeferences and points on the sea (i.e. coordinates that did not project onto land) were removed from the dataset. New records were manually compiled through classical literature research. For specimens reported in the literature without georeferences but with an accurate description of the collection locality, coordinates were assigned using Google Earth. All the georeferenced records (GBIF + literature) were used for the mapping and the comparative analysis.
As a result, we can conclude that the two datasets provide quite significantly different information and the combination of the two offers new information that would not exist in a single data source. Nevertheless, a careful quality evaluation of the primary information, both in the case of literature and GBIF should be conducted, before the data is used for further analyses.

34-P   COXI – extract: a new bioinformatic tool for COXI retrieval aimed at DNA-barcoding of animal species.   _Bachir Balech [1] - Monica Santamaria [1] - Giuseppe Corriero [2] - Cataldo Pierri [2] - Marinella Marzano [1] - Carmela Gissi [3] - Graziano Pesole [1]_

Institute of Biomembranes and Bioenergetics, CNR), Bari, Italy [1] - Department of Biology, University of Bari "Aldo Moro", Bari, Italy [2] - Department of Biosciences, Biotechnology And Biopharmaceutics, University of Bari "Aldo Moro", Bari, Italy [3]

The mitochondrial gene coding for cytochrome oxidase subunit-I (_COXI_) is widely used as DNA barcode for animal species identification. The DNA barcode itself consists of an approximately 650 bp DNA fragment, falling at the 5' half of the _COXI_ gene. The optimal barcode features of this sequence region derive from the occurrence of highly conserved flanking region for primers design, its appropriate length and the amount of sequence variability. These qualities allow either to discriminate between most of animal species including those closely related or to flag an ambiguous sequence to a known taxon. DNA barcoding may complement or, in some cases, replace the morphological identification of living organisms by providing a very practical and flexible framework for identifying and monitoring biodiversity including alien and/or invasive species. Even if this type of analysis is based on quite standardized molecular and bioinformatics procedures, they usually need custom optimizations related to the taxonomic group under investigation. In this respect, two important issues are: 1) the choice of the most efficient and universal primer pairs for the barcode amplification in the entire taxonomic range of interest; 2) the availability of comprehensive and taxonomically curated datasets of

reference barcode sequences (in particular, their collection and validation from the world-wide databases is not a trivial matter). In this context, we developed *COXI* – Extract, a broad-spectrum *COXI* DNA barcode query system. In its current version, it queries the Barcode Of Life Data systems (BOLD) and the Nucleotide database of the NCBI Center and retrieves all available *COXI* sequences belonging to a user-defined taxonomic group. The following elaboration consists of two steps. The first is the comparison of all selected sequences with taxon-specific *COXI* profiles to validate their taxonomy and to ensure their correct assignment as *COXI*. The second one is the mapping of each sequence on a reference *Mus musculus COXI* gene to confirm whether it belongs to the barcode region. All sequences satisfying these criteria are then provided, together with their taxonomy classification at six levels, from phylum to species. Names and sequences of recorded PCR primers used for the amplification of extracted sequences are also provided. By allowing to rapidly access all barcode *COXI* sequences in a given taxonomic range together with the primer sets effectively used for their amplification, *COXI*- Extract valuably support researchers involved in alien species molecular censoring, by contributing to both experimental and bioinformatic analysis of unknown or ambiguous animal specimens. Here, we present the results obtained by its application on Crustaceans, which include a number of documented Italian alien species. *COXI* – Extract is currently implemented as a REST web service and it will shortly be available as a web application easily accessible even by non-experts.

34-P   Fecundity of a native herbivore on its native, invasive and hybrid host plants in relation to plant chemistry.   *Michelle Marko [1] - Raymond Newman [2]*

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The host range expansion of the specialist weevil, *Euhrychiopsis lecontei*, from the native northern watermilfoil, *Myriophyllum sibiricum*, to the invasive Eurasian watermilfoil, *Myriophyllum spicatum*, is one of the few examples of a native insect herbivore preferring, growing and surviving better on a nonindigenous host plant than it does on its native host plant. We evaluated how weevil fecundity on *M. spicatum*, *M. sibiricum* and *M. spicatum* x *M. sibiricum* hybrid milfoils was affected by host plant quality of juvenile rearing and adult feeding and oviposition plants. When weevils were collected from and exposed to milfoils collected directly from the lake, *M. spicatum*-reared weevils had higher fecundity and greater preference for *M. spicatum* over *M. sibiricum*. When weevils were reared on and allowed to oviposit on milfoils grown in a common garden experiment, the difference in fecundity and preference for *M. spicatum* over *M. sibiricum* or *M. spicatum* x *M. sibiricum* hybrid watermilfoils diminished. The differences in plant chemistry mirror these results with lake collected *M. spicatum* having higher carbon concentration and carbon-based secondary metabolites, whereas *M. sibiricum* had a greater concentration of ash. The specialist milfoil weevil's preference for *M. spicatum* was impacted by changes observed in plant chemistry. The presence of ash as a deterrent in *M. sibiricum* may have led to the co-evolved weevil's greater fecundity and host range expansion to *M. spicatum*.

34-P   Role of the invasive amphipod *Gmelinoides fasciatus* (Crustacea: Amphipoda) in benthic invertebrate communities in Onego Lake.   *Anastasiya Sidorova, Natalia Belkina*

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Since the middle of the XX century, the rapid spread of alien species and their successful penetration in natural and artificial ecosystems has led to significant environmental changes all over the world (Panov et al., 2007, 2010; Strayer, 2010; Keller et al., 2011). The new invader of Baikalian origin *Gmelinoides fasciatus* (Stebbing 1899) was recorded in littoral zone of Onego Lake in 2001 (Berezina, Panov, 2003). Onego Lake, the second largest lake in Europe, has still been steady enough to invasions of species which have already shown their high invasive potential. To assess the role of the invasive amphipod in benthic invertebrate communities hydrobiological samples were collected during the vegetation period from three distinct littoral biotopes: reed beds, stones and sand in the Puhtinskaya area of Onego Lake. According to the study results, during the vegetative season the average density of macrozoobenthos associated with the reed beds was 2692 ind. m−2, biomass – 4.8 g m-2. It is a well-known fact, that macrophytes enrich the biodiversity and abundance of benthic organisms (Schmieder, 2004). A total of 16 taxonomic groups were identified from the benthic fauna of Onego Lake. In terms of abundance, the main taxonomic groups were Amphipoda, Chironomidae, Oligochaeta, Ephemeroptera, Trichoptera, Coleoptera and Mollusks. The average density of the stony community was 2549 ind. m−2, average biomass 3.4 g m-2, while in sands area the average density of macrozoobenthos 85 ind. m−2, average

biomass – 0.081 g m-2. In all studied sites *Gmelinoides fasciatus* (Stebbing 1899) was the only species of order Amphipod. This species was dominant in all studied habitats in relation to its abundance (45-67%) and biomass (47-90%). It was revealed, that during the vegetation period the dynamics of biomass and abundance has 2 peaks (late June and late August). It was shown that on the northern border area of the European part of Russia (Onego Lake) the invader *G. fasciatus* has a one-year life cycle with the generations of the previous and current years. Recent data also show that the invasive amphipod spread in the littoral zone of the east part of the lake. And nowadays it is dominant on the biomass among macrozoobenthos on stones littoral biotopes of the islands and east part of Onego Lake.

35. DORMANCY IN AQUATIC ECOSYSTEMS

35-O Summer diapause in Cyclopoid copepods of boreal lakes: a complex response to changes in morphometry, trophic status, hypolimnetic anoxia, and predation pressure.   *Bernadette Pinel-Alloul* [1] *- Victor Alekseev* [2]

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Cyclopoids copepods are a dominant component of freshwater zooplankton in the Nearctic region of North America and the Cyclopidae is the most diverse family. Diapause is a fundamental process of cyclopoid life history in permanent lakes and temporary ponds, more often in temperate than in tropical regions. In boreal lakes, cyclopoid diapause has been documented mainly in Northern Europe, but more rarely in Northern America. We present the first study on summer diapause patterns in cyclopoid copepods (SDC) in 22 boreal lakes in southern Québec, which vary in their morphometry, tropic status and predation pressure by fish or invertebrates. We developed a conceptual model to test the hypothesis that variation in the composition and abundance of SDC in boreal lakes is a complex response depending primarily on morphometric and trophic features and secondly on the intensity of hypolimnetic anoxia and predation by vertebrates or invertebrates. Using morphometric indices, lakes were classified in groups varying by the importance of wind mixing, the strength of thermal stratification during summer, the potential of meromixis, and the risk of predation by fish or chaoborids. Three cyclopoid species (*Diacyclops thomasi*, *Cyclops scutifer*, *Mesocyclops edax*) dominated in all groups of lakes, while *Diacyclop nanus* and *Acanthocyclops vernalis* were found in small abundance and few lakes. The highest densities of dormant cyclopoid stages (up to 500 000 ind m^{-2}) were found in sediments of thermally stratified mesotrophic lakes with intermediate potential for meromixis (Pm). In lakes with low Pm as well as with high Pm, accumulation of diapausing cyclopoids in sediments was low. Strong positive correlations were also found between dormant copepod densities and lake productivity indexes (total phosphorus and chlorophyll concentrations, water transparency). *Chaoborus* larvae density and permanent fish population negatively correlated with diapausing cyclopoid abundances in profundal micro-benthos. Fish presence, lake morphometry and trophic status as well as *Chaoborus* predation are the key factors governing density and biodiversity in summer diapausing cyclopoids in stratified and wind-mixing lakes.

35-O The role of refractory phase in diversified bet-hedging lifespan of diapause in *Daphnia*.   *Mirek Slusarczyk, Wojciech Chlebicki, Tomasz Karasek, Jacek Radzikowski*

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Our recent computer simulations anticipated evolution of diversified bet hedging lifespan of diapause as an ultimate element of life strategy of virtual organisms inhabiting unpredictably changing isolated habitats.
In the present study we aimed to test some predictions of our model and investigate potential role of a refractory phase (the insensitive period in ontogenesis of resting forms to reviving stimuli) in shaping the length of diapause in some freshwater crustaceans.
In laboratory tests we compared the length of refractory phase of resting eggs of planktonic cladocerans originated from different waterbodies and seasons.
We collected cohorts of ephippial eggs of *Daphnia magna* in spring and autumn in erratic city ponds and exposed them to favourable hatching stimuli after various periods of enforced dormancy (temporal storage in cool and dark conditions).
The hatching proportion in all groups of diapausing eggs increased linearly along weeks of the enforced dormancy what may support implications of our simulations. While small proportion of ephippial eggs that were formed in autumn developed without any delay, all ephippial eggs produced in spring resumed development after at least a few weeks of developmental arrest.
In the similar way we compared the hatching pattern of ephippial eggs of *D. longispina* formed in autumn in permanent dimictic lakes with ones produced in erratic city ponds. The results will be presented once the experiment is completed.

35-O The effect of gamma radiation and heavy metals on survival and hatching success of resting eggs and life cycle parameters of hatchlings from exposed eggs of cladoceran *Moina macrocopa*.

Egor Zadereev [1] - *Tatiana Lopatina* [1] - *Natalia Oskina* [2] - *Tatiana Zotina* [1] - *Dmitry Dementyev* [1]

Institute of Biophysics Sb Ras, Institute of Biophysics Sb Ras, Krasnoyarsk, Russian Federation [1] - *Department of Fundamental Biology And Biotechnology, Siberian Federal University, Krasnoyarsk, Russian Federation* [2]

Aquatic ecosystems are contaminated with various anthropogenic toxicants. A lot of studies is focused on the effect of toxicants on the life cycle or population parameters of zooplankton. Many zooplankton species, specifically cladocerans, under the unfavorable conditions produce resting eggs that form egg banks in the bottom sediments. Egg banks are important for ecology and evolution of aquatic communities. At the same time, bottom sediments serve as a sink of antropogenic inputs including toxic ones. While little is known about the effect of different toxic agents on the resting eggs of Cladocera. In this study we investigated the effects of gamma-radiation from the point source of cesium (137Cs) and the effects of the heavy metals (copper, cadmium, nickel and zink) on the survival and hatching success of resting eggs of cladoceran *Moina macrocopa* and on the parameters of the life cycle of hatchlings from exposed eggs. It was shown that gamma-radiation in a wide range of doses (from the background level to 100 Gy) had no effect on survival of eggs and mortality of animals hatched from irradiated eggs. However, exceeding the absorbed dose of 40 Gy sharply decreased reproductive potential of the animals hatched from irradiated eggs. It was shown that resting eggs of cladocerans *M.macrocopa* had a high resistance to heavy metals. Survival of resting eggs and life cycle parameters (lifespan, juvenile growth rate, the number of hatched clutches and net reproductive success) of hatchlings from dormant eggs that had been exposed to heavy metals in a wide range of concentrations (from baseline to 60-70 g/L) did not differ from control eggs and animals. The data suggest that the accumulation of man-made radionuclides in sediments can have a significant impact on aquatic ecosystems, through chronic adverse effects on the dormant eggs, while the toxic effect of heavy metals will be critical for active animals and relatively safe for resting stages.

35-O Do dormant forms shed by *Daphnia* on the water surface differ from ones laid in the water column?

Ewa Narożniak, Jacek Radzikowski, Mirosław Ślusarczyk

Departament of Hydrobiology, University of Warsaw, Warsaw, Poland

Crustaceans of genus *Daphnia* may produce two kinds of eggs: subitaneous or diapausing ones. The resting eggs are protected by a hardened chitynous coat called ephippium. Ephippium with the resting eggs may be shed by a female in the water column (and then it commonly sink to the bottom and reside in the native habitat), or be oviposited on the water surface, what may facilitate their passive dispersal.

The aim of the present study was to determine if these two groups of dormant forms that may play different functions differ morphologically or physiologically. Ephippia were collected from the bottom and the water surface in two lakes. All ephippia and ephippial eggs were measured and their weight was compared. Number of full, semifull and empty ephippia were counted in the each group. Moreover, the resistance of the ephippial eggs to temporal desiccation or exposition to extreme temperatures was examined.

The results indicate the two groups of dormant eggs may differ in morphology and resistance to the tested environmental extremes what may be associated with the different function they possibly play.

35-O Bio pollution in Russian Arctic: dormant stages in ship ballast water.

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Human mediated dispersal of alien aquatic organisms is a longstanding serious ecological problem in aquatic ecosystems around the World. Ship transportation of huge amount of ballast water, containing resistant dormant stages provide a good possibility for many previously isolated species to cross geographic barriers. As a result, new species from America and Asia appeared in Europe, and vice versa. Most of the newcomers belong to temperate and tropical climate zones (thus implying short to medium distances) which could be a result of mortal temperature selection as many species in

ship ballast compartment cannot survive during long voyages. The alternate temperature selection process of organisms can also be found in tankers and cargo ships which sail nowadays via the Northeast Passage. This Arctic shipping route was more or less effectively used by the Soviet Union in 1930th-1980th but its effect on alien species distribution has never been studied. In the beginning of the 21th century, the Earth warming and Arctic sea ice melting have created new opportunities for shipping, but also for the transportation of alien species in the Arctic. This poster will discuss the first scientific results of aquatic biological invasions in coastal zones of the Russian Arctic and the influence of the increasing use of the Northeast Passage on the region's biodiversity. Supported by RFBR grant N 14-04-00932 and by SSHRC grant 122521 2013-2016.

35-O Capturing zooplankton species diversity over time through the propagule bank.   *Elizabeth Walsh , Sergio Samaniego*

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Many zooplankton species occurring in temporary habitats persist during droughts as resting stages that serve as colonists during subsequent rainfall events. Here we investigate how the length of desiccation impacts community structure and species persistence. We compare species composition of active communities with those formed after extended periods of desiccation (up to 17 years) in numerous temporary desert ponds to determine how the length of dormancy affects hatching success in temporary desert aquatic habitats. Active populations from 10 temporary desert ponds were collected using a 64 um plankton net over 17yr. Sediments from these ponds were collected during dry phases and then rehydrated and emerging taxa were identified. Rotifers were identified to the species level, while other taxa were identified to family. Results showed that a subset of species found in active ponds hatched from desiccated sediments but unique taxa were also found. For example, rehydrated sediments from a small rock pool in 1998 yielded eight rotifer species, one fairy shrimp, a gastrotrich, and an assortment of protists when rehydrated 17 years later. The active community of the temporary pond being investigated consists of 19 rotifers, several cladocerans, and a suite of other invertebrates. Three-year-old sediments from an Australian temporary lake were also rehydrated and 25% of the rotifers present in active communities were recovered. These results are comparable to those found in a similar study in Australia where 19% of rotifer species were recovered from sediments. Our results will help better predict how climate change induced shifts in precipitation may impact patterns of zooplankton community structure in aquatic systems in arid and semi-arid lands.

35-P   A proposal to construction an internet based catalog to document diapausing embryos (resting eggs) in phylum Rotifera.   *Elizabeth Walsh* [1] *- Linda May* [2] *- Robert Wallace* [3]

Department of Biological Sciences, University of Texas at El Paso, El Paso, United States [1] *- Centre for Ecology & Hydrology, Natural Environmental Research Council, Edinburgh, United Kingdom* [2] *- Department of Biology, Ripon College, Ripon, United States* [3]

We surveyed the literature (>130 published reports) to document sexuality in monogonont rotifers, including reports of resting eggs (diapausing embryos; DEs), males, and hatchlings from sediments. Of 30 families, 27 possess species with documented occurrences of sex. Information on DEs is lacking in 41 genera. Of ~300 species with evidence of sexuality (~20% of ~1500 monogononts), only 172 had direct observations of DEs; in the others, DE production was inferred from observations of males and/or hatchlings from sediments. DEs are sufficiently widespread to affirm that their presence is plesiomorphic, however few DE characteristics show a phylogenetic signature. To our knowledge, no systematic catalog of rotifer DEs is widely available. A compilation of this information, especially including photomicrographs, would be valuable to researchers studying zooplankton population dynamics, paleolimnology, and rotifer phylogeny. Thus, we propose development of an electronic database that documents observations of DEs. Ultimately, we envision this repository to be similar to the Rotifer World Catalog or the Rotifer Trophi Web Page. This database should provide basic information including 1 nomenclature, 2 photomicrographs (light microscopy and/or and SEM), 3 DE morphology (e.g., measurements, surface features, and mode of deposition), 4 collection information (e.g., collector, collection date, location, habitat, and basic physical and chemical features of the site), as well as (5) other evidence of sexual reproduction (i.e., presences of males, and/or hatchlings from sediments). We seek researchers who are willing to share their data to advance this project.

35-P   The internal structure of ephippial wall in Cladocera.   *Jacek Radzikowski* [1] *- Piotr Bernatowicz* [2] *- Bohdan Paterczyk* [3] *- Mirosław Ślusarczyk* [1]

Department of Hydrobiology, Faculty of Biology, University of Warsaw, Warsaw, Poland [1] *- Department of Paleobiology and Evolution, Faculty of Biology, University of Warsaw, Warsaw, Poland* [2] *- Laboratory of Electron and Confocal Microscopy, Faculty of Biology, University of Warsaw, Warsaw, Poland* [3]

Diapausing eggs of many cladocerans are encased in external structures known as ephippia. Those protective envelopes differ in morphology and size between cladoceran species. The external structure of the ephippia has been studied thoroughly in the recent years (with the scanning electron microscopy techniques mostly). On the contrary, the internal structure of the ephippia remains poorly explored so far. In the present study we aimed to investigate internal structure of the ephippia of a few cladoceran species using non-invasive techniques of confocal microscopy. We obtained three-dimensional images and two-dimensional sections of ephippia formed by seven species of the family Daphiidae (*Daphnia pulex, D. lumholtzi, D. magna, D. longispina* complex, *Scapholeberis rammneri, Simocephalus vetulus* and *Ceriodaphnia sp.*) and by one chydorid species (*Alonella nana*). In the walls of all the examined daphniid ephippia we observed a "cellular" structure resembling a honeycomb. What is interesting, the interior of the observed "honeycomb cells" differs between species. In most of the ephippia formed by daphniids the "honeycomb cells" were empty (filled with liquid only), while in the ephippia of *Ctenodaphnia* (*D. magna* and *D. lumholtzi*) the "cells" were filled with a spongy chitinous structure. We hypothesize that this spongy structure may deter the air from penetrating the "honeycomb cells" when the ephippium happens to appear at the water surface. Ephippia lacking the spongy structure (e.g. those formed by *D. pulex*) may absorb the air readily, once they appear at the water surface, what makes them permanently buoyant and facilitates their passive dispersal. On the contrary, the ephippia of Ctenodaphnia, having the "spongy walls", achieve permanent buoyancy only after being air-dried.

35-P   Cross-taxon concordance of egg bank and active metacommunities in steppic shallow lakes.

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Shallow lakes are excellent systems to evaluate the possible use of egg banks to assess zooplankton diversity. In this study we evaluated the structure of invertebrate egg banks across 30 shallow lakes located in the Iberian Peninsula by means of hatching experiments. We also evaluated cross-taxon concordance in species richness and community similarity between the dormant and the active metacommunity, and searched for concordant patterns between this dissimilarity and the environment. We observed 30 taxa among all the hatchings, mostly belonging to Ostracoda, Cladocera and Copepoda. A high disparity of hatching patterns was found in the egg bank experiment, reflecting a wide diversity of responses among different lakes' sediments exposed to similar conditions. Protest and correlation analyses reflected a concordance in community similarity between dormant and active organisms. Dissimilarity distances were correlated with environmental variables (% evaporite rocks and ECELS index). Our results demonstrate the concordance of resting egg banks with active communities in shallow lakes. This work was supported by the project *ECOLAKE* (CGL2012-38909).

36. SPRINGS: WELL-KNOWN GROUNDWATER RESOURCES, DISREGARDED BIODIVERSITY HOTSPOTS

36-O   State of play more than 50 years after the recognition of spring biology.   *Marco Cantonati* [1] - *Reinhard Gerecke* [2] - *Lawrence E. Stevens* [3] - *John D. Wehr* [4]

Limnology & Phycology Section, Museo delle Scienze - MUSE, Trento, Italy [1] - *Institute of Evolution and Ecology, University of Tübingen, Tübingen, Germany* [2] - *Springs Stewardship Institute, Museum of Northern Arizona, Flagstaff, United States* [3] - *Louis Calder Center - Biological Field Station, Fordham University, Armonk, United States* [4]

Springs are unique habitats, and feed a variety of characteristic groundwater-dependent ecosystem (GDE). As GDE they provide a range of ecosystem services that span from material (high-quality water) and immaterial (the fascination these sites have always exerted on human cultures) resources to outstanding value for freshwater biodiversity conservation. However, these habitats are under severe threat (mainly because of diffuse and increasing capturing for exploitation), and they likely persisted as special environments only because they are very numerous and because also springs with commercially-irrelevant discharge can host a wealth of biodiversity. Keeping in mind the development of crenobiology since its definition, we want to synthetically discuss recent progress by means of selected results from our studies and/or the literature. Topics that will be synthetically addressed include: spatial heterogeneity at different scales, springs as multiple ecotones, disturbance in springs: low or high, spring-habitats: from extremely-isolated to connected, direct and indirect impacts, taxonomy of spring organisms, biology of spring organisms, least-impaired habitat relics, crenophilous and crenobiontic taxa, peculiar features of spring assemblages, functional studies, the aquifer-spring system and springs as GDEs (crenoecology meets hydrogeology). Fifty-three years after the publication of the definition of crenobiology, spring habitats started gaining some recognition within limnology (articles on the leading journals, dedicated sessions at meetings), there are active research groups specialized on the topic in many countries and widely-distributed internationally, spring habitats are warranted some protection in the frame of nature-conservation legislation in several countries. However, huge challenges need to be addressed and won if we want springs to survive as natural habitats that can be shrines of freshwater biodiversity for the future generations: Appreciation by managers, opinion makers, and non-technical persons needs to be generated and greatly expanded internationally, specific legislation for their protection must become widespread globally, a strong international network among groups involved in spring-habitat research must be created, and representative spring habitats should become long-term ecological research sites within a global network.

36-O   Springs ecosystem ecology and stewardship: neglect has created a global environmental crisis.
Lawrence Stevens [1] - *Jeri Ledbetter* [1] - *Abraham Springer* [2] - *Marco Cantonati* [3] - *David Kreamer* [4]

Springs Stewardship Institute, Museum Of Northern Arizona, Flagstaff, United States [1] - *School Of Earth Sciences And Environmental Sustainability, Northern Arizona University, Flagstaff, United States* [2] - *Limnology & Phycology Section, Museo Delle Scienze, Trento, Italy* [3] - *Department Of Geoscience, University Of Nevada,, Las Vegas, United States* [4]

Springs are ecosystems where groundwater is exposed at and usually flows from the Earth's surface. They are geomorphologically diverse and ecologically important, supporting high levels of biological diversity and endemism, more than 10 percent of US endangered species, as well as thousands of rare but poorly known species. US springs generate more than $10 billion/yr in water sales, with similar levels of importance elsewhere. However, on a global basis, springs are poorly mapped, inadequately managed and insufficiently understood, and few springs are monitored or remain sufficiently ecologically intact to serve as scientific reference sites for restoration planning and implementation. The alteration and loss of springs ecosystems is a little-recognized global environmental crisis, warranting local, national and international attention. Here we document nine reasons for the demise of springs ecosystem stewardship. 1) Etymologically, the English language has three meanings for the word "spring", diluting appreciation of their ecological significance. Not the case in other languages, this is particularly unfortunate as English has become is the dominant language of science. 2) Although springs are ecologically influential, most are small in area, falling within rather than among pixels in land surveys, and are thus overlooked. 3) Every society on Earth except the

modern Anglo-European culture regards springs as sacred places, but springs are rarely managed for such values. 4) Springs are jealously guarded as sources of clean water, and information about them and access to them are often restricted. 5) Western culture emphasizes exploitation over maintaining springs as natural resources. 6) The potential for exploration of springs and groundwater hydrology in art is great, but has been largely overlooked. 7) Despite the formulation of ecosystem ecology by Odum in 1957 at Silver Springs, Florida, subsequent ecosystem study has been limited. Such research requires multidisciplinary collaboration among hydrogeologists, geographers, ecologists, socio-cultural researchers, economists, and others, but insufficient collaboration has occurred. 8) Many recent management-oriented texts on ecohydrology, wetland science and stewardship, and the state of national and global aquatic ecosystems scarcely mention springs. 9) Confusion over springs, stream, and wetland classification systems in governmental policy has limited legal recognition and management. Consequently, springs ecosystems are nearly everywhere threatened by the anthropogenic impacts of groundwater overdraft and pollution, poor land use practices, and mismanagement. However, if the supporting aquifers are intact, springs ecosystems can readily be rehabilitated, and natural ecosystem function can be restored. We describe examples of these societal, scientific, and managerial failures and their ecological consequences, as well as successful efforts to rehabilitate springs ecosystems.

36-O   Springs as models to study complex ecosystem functioning.   *Andreas Schweiger, Carl Beierkuhnlein*

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The understanding of complex ecosystem functioning is increasingly realised to be crucial to develop sound adaptation and mitigation strategies against ongoing environmental changes. Complex ecosystem behaviour like ecosystem resilience, the emergence of alternative stable states as well as the scale- and path-dependence of ecological processes is a fundamental property of ecosystems to sustain ecosystem services like e.g. water provisioning.
Although the theoretical concepts dealing with complex ecosystems were introduced decades ago, exhaustive empirical tests for these concepts are still missing. Here we argue that seepage springs are ideal model ecosystems to study complex system behaviour for natural systems. We therefore analysed long-term data of water chemistry and plant community composition for seepage springs in the lower mountain ranges of Central Germany. By spanning a period of 25 years, this dataset recorded the ecological long-term response to historic as well as recent environmental stressors including anthropogenic acidification during the 20th century as well as recently emerging climatic extreme events.
Based on this long-term dataset we were able to study several principles which qualify springs to be complex adaptive systems. Strong interactions between historic and recent environmental stressors were identified to synergistically affect response trajectories and alternative states of the studied spring communities. Furthermore, adaptive feedbacks between the changed environmental conditions and ecosystem engineering species were observed to stabilise alternative states in plant community composition over decades. All these facts characterised the studied springs to be complex adaptive systems. To understand the reaction of such systems to upcoming environmental changes integrative studies which specifically tackle the complex nature of ecosystems are increasingly needed.
The results presented here provides a first step towards complex system thinking for springs, ecosystems which are highly valuable for service provisioning (e.g. water supply) but which are completely underrepresented in research up to now.

36-O   Water mites (Acari: Parasitengona: Hydrachnidia) as inhabitants of groundwater-influenced habitats in Europe.   *Reinhard Gerecke*

Evolutionary Biology of Invertebrates, Eberhard-karls-universität, Tübingen, Germany

No other invertebrate group includes such a high number of species with a particular relationship to spring habitats as water mites (Hydrachnidia). Based on actualized data from all parts of the continent, this phenomenon is analyzed for the 1115 species at present known from Europe. The following questions are addressed: 1 Significance of spring habitats for the diversity of water mites – percentage of crenobionts/crenophiles at different geographical latitudes; 2 Regional stenotopy – intraspecific differences in habitat preference between populations at different latitudes; 3 Communities

colonizing springs vs. hyporheic interstitial – similarities and differences; 4 Evolution of crenobiosis in water mites – potential governing factors; 5 Endangered species – direct and indirect anthropogenic threats to water mites diversity.

36-O   Diatom assemblages distribution in springs from various geological formations (Southern Poland).   *Agata Wojtal*

Institute of Nature Conservation, Polish Academy of Sciences, Krakow, Poland

The character of spring water reflects not only local factors but also, and primarily, processes of natural or anthropogenic origin throughout the groundwater basin. The physical and chemical properties of spring water are related to an area's geology, climate and land use. They reflect the mineral composition of the rock with which the water has been in contact and geological processes in the surroundings. The properties of natural spring water can be altered directly by pollution from nutrients and other contaminants, and consequently accelerating bedrock leaching. Especially in the limestone areas common in southern Poland, pollutants can easily migrate through natural conduits into aquifers, contaminating them for decades.

Over hundred springs were sampled covering a wide range of chemical water properties. The statistical analyses showed that the diatom species distributions are controlled by both natural and anthropogenic factors. The most important factors influencing species distributions were specific conductance, calcium, magnesium, potassium and nitrate concentrations.

The most common diatoms were *Achnanthidium minutissimum*, *Planothidium lanceolatum*, *P. frequentissimum*, *Amphora pediculus* and *Caloneis fontinalis*. Amongst the other common and abundant diatoms, the ones with the broadest range of environmental variables were those having optima in waters with high or very high concentrations of nitrates, calcium, magnesium, potassium and sodium and with moderate dissolved oxygen content, such as *Diploneis krammeri*, *Navicula cincta*, *Nitzschia frustulum* and *Planothidium frequentissimum*. The diatoms having the narrowest ranges but varying greatly in the strength of a given factor were species such as *Diadesmis perpusilla*, *Fragilaria rumpens*, *Gomphonema angustatum*, *Navicula striolata*, *Nitzschia fonticola*, *N. alpina*, *Psammothidium grischunum* and *Tetracyclus rupestris.*

Several rarely reported species were recorded including e.g. *Crenotia angustior*. The specific chemistry of the spring waters and the isolation of these springs were reflected in the very diverse composition of diatom assemblages.

36-O   A proposed framework for testing functional biodiversity of algal assemblages in springs.
John Wehr

Louis Calder Center - Biological Field Station, Fordham University, Armonk, United States

Studies have shown that spring ecosystems can be centers of high biological diversity and may also harbor endemic or unusual species not seen in other aquatic habitats. Studies have demonstrated that algal assemblages in karst springs and streams follow this pattern, with high taxonomic taxa richness and unique species of diatoms, green algae and cyanobacteria. However, it has not been clearly shown from an ecosystem perspective, whether algal biodiversity results in greater functional diversity. Some studies have demonstrated a correlation between community structure and function in aquatic systems, but this has yet to be rigorously examined in spring ecosystems. This presentation outlines a framework, with proposed metrics that may be used in future studies in spring ecosystems to test whether high taxonomic and/or genetic diversity affects ecosystem function, such as in energy flow, material cycling, or ecological resilience. To test possible links with ecosystem function, we propose these metrics as measures of functional biodiversity: 1 primary production, 2 habitat heterogeneity and complexity, 3 nutritional quality of algal assemblages as a basal food source, 4 nutrient retention and recycling, 5 herbivore diversity, and 6 consumer production. We plan to examine these metrics in a cluster of karst springs within the Nittany Arch, a karst region in the Appalachians of central Pennsylvania. It is a region whose carbonate aquifers, water chemistry and geology are well known, but whose biological and ecological properties are in need of study. - Predictions: (a) While algal biodiversity will not directly correlate with greater primary production, it will lead to more stable (over time) and resilient (in response to changes in water flow) production within springs. (b) Greater algal biodiversity will enhance structural diversity (and hence niche space) for microbes and invertebrates. (c) Food web benefits of greater algal biodiversity will be evidenced in greater nutritional

quality of basal food sources, measured in lower C:N and C:P stoichiometric ratios, higher concentration and wider diversity of polyunsaturated fatty acids (PUFAs), a greater ratio of $\omega3/\omega3$ PUFAs, and higher protein:C ratios. (d) Greater functional diversity in algal assemblages (as measured by these metrics) will also lead to greater herbivore diversity and consumer production.

36-O   Conserving islands in the desert - the intersection of endemic biodiversity and threat in Australian arid zone springs.

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Springs are often "hot spots" of freshwater diversity, particularly in arid contexts, but are generally overlooked in broader limnology. Despite their geographical and physical differences, springs across the globe share a history of habitat destruction and biodiversity loss. In Australia, springs that emerge from the nations largest aquifer (the Great Artesian Basin, G.A.B.) span over a third of the continent and provide essential habitat to ~95 narrow-range endemic species, however in the past two centuries an estimated 50% of springs have disappeared. I will present a brief summary of G.A.B. springs, and highlight some of the major findings of an ongoing collaborative effort to survey their current status, the patterns of biodiversity within them and some of the processes that may limit the distribution of endemic springs species. Using historical ecology, GIS, field survey and physiology our research team attempt to highlight the linchpins for conserving springs biodiversity in Australia and provide mechanistic clues to how threatening processes jeopardise this diversity.

36-O   The phycological biodiversity of springs and wells in Egyptian oases, and first attempts to use it for assessment purposes.

Abdullah Saber [1] *- Marco Cantonati* [2]

Faculty of Science, Ain Shams University, Cairo, Egypt [1] *- Museo Delle Scienze - MUSE, Trento, Italy* [2]

Spring habitats, and their artificial counterpart "wells", are usually considered hydrochemically-stable, "azonal" environments with low nutrient levels. However, these unique ecosystems can suffer intensive pollution and nutrient enrichment due to diverse direct (e.g., agricultural activities and cattle breeding) and indirect (e.g., excess nitrogen and heavy-metal deposition) human impacts. The PhyBiO Project (The **Phy**cological **Bi**odiversity in Egyptian **O**ases, and Challenges for its use in the Bioassessment of Water Resources) of the Museo delle Scienze – MUSE, Limnology and Phycology Section, Trento (Italy) so far allowed to unveil and characterize a remarkable algal and cyanobacterial biodiversity from Egyptian desert springs and wells using an in-depth modern polyphasic approach. To date, the results revealed some new to science or poorly-known species belonging to the green-algae genera *Rhizoclonium*, *Caespitella*, and *Cloniophora*, and to the diatom genera *Achnanthidium* and *Seminavis*, and some other new records for Egypt (e.g., *Westiellopsis prolifica, Sellaphora nigri, Zygnema czurdae*, and *Zygnemopsis* sp.).

Benthic algae and cyanobacteria are remarkably related to ecomorphological spring types, and might therefore successfully be used in the development of benthic-algae-based, spring-habitat-specific bioassessment systems. At present, our main ongoing task is working out the pre-requisites, i.e. the sound taxonomic and ecological characterization of the most frequent, abundant, and specific algal and cyanobacterial taxa, for the development of state-of-the-art algal and cyanobacterial ecological assessment tools for these desert ecotonal habitats to characterize their biological integrity and trophic status. We believe that future indices should be based on the detailed identification of species and on their abundances recorded combining abundances measured microscopically with % cover data collected in the field, following European standards adapted to spring habitats. Another interesting goal might be the development of a "Red List" of the benthic algae and cyanobacteria of Egyptian inland-waters to lay the suitable foundations for the conservation of imperilled rare algal taxa.

36-O   Seasonal biodiversity patterns of Chironomidae in relation to thermal regimes of twenty small spring-fed runs in Minnesota.

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Emergence patterns and community richness of Chironomidae were assessed seasonally in twenty small spring-fed runs draining into the Saint Croix River in Minnesota, USA. Emergence was documented using standardized collections of surface-floating pupal exuviae following a protocol of Ferrington _et al._ (1991) at sites with differing spring-water inputs. Isothermal groundwater input of ~8.2 degrees C buffers the daily and annual thermal regimes as a function of total stream flow at sample sites, with sites closet to or most-dominated by spring input being warmer in winter and cooler in summer than sites more removed from spring sources. A cumulative total of sixty-two taxa were encountered in the study, but annual richness within individual spring runs varied from 29 taxa to 41, and differed as a function of stream discharge and extent of thermal buffering. Composition of Chironomidae in all runs was dominated by cool-adapted Orthocladiinae. Sites most strongly thermally buffered remained ice-free in winter and had more winter-emerging species (including Diamesinae) but reduced total annual species richness compared to sites least buffered by spring water. At these least-buffered sites, edge ice or compete ice-cover occurred in winter. Emergence of warmer-adapted Chironomini was minimal, but tended to be most concentrated during summer at sites least buffered by spring water. Averaged across all spring runs, emergence composition was most similar between spring and autumn seasons. Our results show that the tempering of thermal regimes near spring-sources in small runs influences not only the timing of emergence, but the over-all biodiversity patterns of Chironomidae.

36-O   Which species are vulnerable to climate change in alpine springs of Switzerland?

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In the Swiss Central Alps, a study in more than 50 rheocrenes between 1720 and 2515 m a.s.l. was performed, to find out which species will suffer from the consequences of climate change. In each spring site temperature was measured and the fauna was investigated using a standardized protocol. Water temperature showed a significant inverse correlation with altitude and a positive correlation with distance to permafrost in the spring catchment. Springs exposed to north and west were significantly colder than those with south exposure.
Altogether 93 EPT species (Ephemeroptera, Plecoptera, Trichoptera) were found in the springs, of which 37 species (40%) are considered as crenobiont or crenophilous. With rising temperature the number of EPT species significantly increased. By examining each taxon separately, only the correlation of Trichoptera and temperature proved to be significant, which can be explained by a high number of cold stenothermic species among the Plecoptera. Other parameters like structural properties, spring area or discharge did not show significant correlations with temperature. Currently ongoing examinations of the data are aiming to reveal vulnerabilities of individual EPT taxa towards climate change.

36-O   Evolution, diversity, and potential impacts of climate change on spring-inhabiting caddisflies of the subfamily Drusinae.

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Within Palearctic Trichoptera the subfamily Drusinae comprises roughly 100 cold-adapted species and represents one of the most diverse crenophilous groups. Additionally, it exhibits complex feeding ecologies comprising three monophyletic larval feeding groups: filtering carnivores, scraping grazers and omnivorous shredders.

Using a multi-locus (6 gene fragments; 3805 bp) molecular phylogeny we infer species-level relationships within Drusinae. We identify larval and adult morphological synapomorphies of the larval feeding groups and locally distributed subclades. Phylogenetic analysis suggests multiple independent invasions of rhithral stretches within the filtering carnivores and several scraping grazer subclades. Interestingly, larvae in these clades differ strikingly from the basic Drusinae larval *bauplan*, and are characterized by modifications of head capsules, setation patterns and pronota.

We also model distribution patterns of Drusinae and projecte potential range shifts under four future climate scenarios. Results suggest that the majority of Drusinae will experience contractions as well as geographic and altitudinal translocations of climatic niches. Generalized, they further indicate an elevated threat of crenophilous groups comprising high numbers of endemic species. We suggest usage of Drusinae as umbrella taxon for the identification of regions most likely to suffer significant losses of endemic aquatic biodiversity.

In the course of the project we identified 19 new species using integrative taxonomy approaches. These findings highlight the significance of integrative alpha-taxonomy in a supposedly well-investigated area, and corroborate the significance of springs as harbours of rare and endemic species.

36-O   Seeking for surrogates: spring biodiversity in human-altered landscapes.   *Jussi Jyväsjärvi [1] - Jari Ilmonen [2] - Risto Virtanen [1] - Lauri Paasivirta [3] - Timo Muotka [1]*

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Springs host a high level of insect and plant diversity, making them key habitats for conservation of biodiversity in forested landscapes. Human-induced degradation and loss of spring habitats and the consequential loss of spring biota have raised a need for the development of spring bioassessment and conservation. We applied boosted regression tree models (BRT) fitted to biological data from 131 springs to identify bryophyte and macroinvertebrate surrogate species for taxonomic and functional diversity. The BRT models suggested that the presence of bryophyte *Bryum weigelii* and the chironomid larva *Paratrichocladius skirwithensis* best indicated overall taxonomic diversity, whereas the isopod *Asellus aquaticus* and the chironomid larva *Macropelopia* spp. were the best indicators of functional diversity. Independent test data from 49 springs confirmed that the springs occupied by *B. weigelii, P. skirwithensis,* or both, had a significantly higher number of spring-preferring specialist (crenophilic) bryophyte and macroinvertebrate species compared to sites with the surrogates absent. Correspondingly, the springs occupied by *A. aquaticus* and *Macropelopia* spp. were functionally more diverse compared to sites without the surrogates. Multivariate ordinations suggested that the sites occupied by taxonomic surrogates were compositionally dissimilar to sites without the surrogates and the assemblages were characterised by the presence of several other crenophilic invertebrate and bryophyte taxa. Finally, we applied a crenophile richness-based complementarity algorithm to select the priority set of springs, using the occurrence of taxonomic surrogates as a classification factor. The complementarity-derived priority sets of springs based on taxonomic surrogates individually or in combination were almost equally effective as was the optimal approach (all sites included) and captured more crenophilic species than selecting sites randomly. The functional diversity surrogates did not differ from random solution, suggesting that protection of sole functional diversity is unlikely to result in improved conservation of taxonomic diversity, and separate surrogates are thus needed for these two facets of spring biodiversity. The four surrogate taxa identified in this study bear great potential in indicating functional and taxonomic diversity of boreal spring ecosystems. In particular, given the ubiquity of *B. weigelii and A. aquaticus* and their relatively easy identification in field conditions, these species are suggested for rapid assessment tools for practical management of spring habitats.

36-O   Human disturbance in springs - assessing the effects of forest drainage and groundwater contamination on the structure and functioning of boreal spring ecosystems.

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Spring ecosystems possess high biodiversity and conservation value. Taxonomic diversity and composition of natural springs have been addressed during the past decades, whereas little is still known about the effects of human-induced stressors on the structure and functioning of spring ecosystems. We evaluated the impacts of forest drainage and groundwater contamination on the diversity and species composition of bryophytes, benthic invertebrates and diatoms, and ecosystem functions (leaf breakdown and periphytic algal accrual, a surrogate of primary productivity) using data from 21 southern Finnish springs. The study springs were either in near-pristine condition (n=7) or were noticeably degraded by forest drainage (n=6) or groundwater contamination (elevated NO_3^- and Cl^- concentration; n=8). The three spring groups showed markedly different environmental characteristics. Drainage-impacted springs received surface water, resulting in increased dissolved organic carbon (DOC) content and thermal instability, whereas the contaminated springs had substantially higher nitrate, chloride and conductivity values compared to drainage-impacted and reference springs. Forest drainage suppressed algal accrual, whereas groundwater contamination had no effect on primary productivity. Microbial decomposition of leaf litter did not differ among the spring groups. Macroinvertebrates showed strongest response to human-induced stressors as their species diversity and species composition in degraded springs differed considerably from those in near-pristine conditions. Bryophyte and diatom species richness were equally high among the spring groups. Diatom species composition in drainage-altered springs differed from the natural conditions, whereas bryophyte assemblages were rather similar among the spring groups. Our results suggest that groundwater contamination may primarily contribute to the structure of biota, while forest drainage impairs spring ecosystem functioning and consideration of both stressors is thus essential in successful management of spring ecosystems.

36-O   Harz mountains springs reflect natural vegetation zones, acidification and mining.

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The Harz Mountains are the most northern one of the European Central Mountains, the so-called "Mittelgebirge". With a maximal altitude of 1,141 m asl. its rough climate is comparable to alpine conditions in altitudes between 1,600 m and 2,200 m asl.. The uppermost parts of the Harz Mountains exeed the natural timber line. Typical of the flora and fauna is a high proportion of glacial relicts and boreal species. Annual rainfall is high (up to 1,600 mm), and the aquifers are characterized mainly by granites and other silicatic rocks. However, in the forelands prevail carbonatic rocks. Mining of heavy metals played a large role from the middle age until the end of the 20th century.
From all areas of the Harz Mountains, 73 representative springs were mapped with respect to structure, surroundings, macrozoobenthos and hydrochemistry. Data analyses showed that spring fauna communities can be classified into three groups, perfectly reflecting the natural vegetation zones along the altitude gradient. Grouping is explained best by acidification parameters like pH-value and buffering capacity, while structure was found to be of secondary importance. DOC, pH-value and iron, electrical conductivity, sulfate and heavy metals were found to be the main parameters shaping spring hydro-chemistry and reflecting both, hydrogeology and human impacts.

36-O   The diversity of aquatic invertebrates in helocrenes: regional and local perspective of the Western Carpathian springs.

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Helocrenes belong to the most threatened inland wetlands. They are fed by groundwater, whose chemical composition determines the main ecological gradient among these habitats. They host a high number of species of aquatic invertebrates, among which specialists may be relatively easily identified. Moreover, helocrenes are mutually isolated,

and for those developed in spring fens it is possible to determine the age of individual sites by radiocarbon dating. This all gives them the power to answer many interesting ecological and biogeographical questions. Despite that, there is a fairly limited knowledge about invertebrate fauna of spring fen helocrenes, main diversity patterns and processes driving the species composition of these assemblages.

At 64 studied sites located in the Western Carpathian Mts we found surprisingly species rich assemblages with many specialized and threatened species. In total we identified 550 taxa (incl. 450 spp.), most of which belonged to Diptera (235, with about 100 taxa of Chironomidae). The number of species recorded at sites was related mostly to chemical composition of groundwater and to discharge. The number of specialist species closely followed local factors (increased with pH), while generalists were most species rich at sites with a high water level stability.

In agreement with available data from headwaters we proved the leading role of local conditions in structuring the assemblages of most taxa groups except for passive specialists, in which a strong effect of spatial organization could be detected.

36-O   Spring benthos communities of middle Volga basin in the conditions of different anthropogenic stress: structural and functional characteristic.   *Tatiana Chuzhekova*

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Spring and spring brooks are the most common water objects in humid zone of Palearctic. During last 20 years, springs have become popular objects of hydrobiologic investigation all over the World, because they as ecotones, integrate ecological processes occurring in groundwater, surface water and terrestrial ecosystems, these make springs particularly sensitive to direct and indirect impacts human (Scarsbrook et al. 2007). That is why interesting to study the differences of benthic communities in springs varying in anthropogenic stress.

It known that spring brooks are wide spread in Middle Volga Basin (East Europe) there both in reserved and urban territories. The material for study was collected in 54 springs and spring brooks during 2006-2012 (907 samples). To classify the anthropogenic stress we used next scale: disturbed (urban territory or highway), hemi disturbed (territory of resorts and villages), undisturbed (territory of national parks). Quantitive samples were collected with surber or Gruzov's grab, qualitative with net. For each sample were estimated total abundance, % of crenophilous taxa from total number, biomass, production using P/B-coefficients (Golubkov, 2000), functional feeding group composition (Asterics 3.31).

For all groups of spring sites was shown high biodiversity (near 250 species for group), total species number is 447. Most abundant there are Diptera – 230 (Chironomidae – 107), Trichoptera – 36, Oligochaeta – 22 и Gastropoda – 20. Usual in all three sites groups were *Tubifex tubifex, Limnodrilus* spp., *Eiseniella tetraedra, Prodiamesa olivacea, Pseudiamesa nivosa, Chaetocladius piger, Dictranota bimaculata*, in disturbed sites - *Dina lineata, Radix labiata, Physa acuta, Chironomus* spp., *Macropelopia nebulosa, Procladius flavifrons, Psectrotanypus varius*, in hemi disturbed - *Tipula luna, Krenopelopia binotata, Micropsectra* gr. *juncii*, Tanytarsus verralli, in undisturbed sites - Baetis rhodani, Nemoura cinerea, *Plectrocnemia conspersa, Satchelliella canescens, Pseudodiamesa branickii, Tanytarsus excavates*. Number of benthic organisms is two time higher in disturbed sites (7,8±1,1 thous. ind./m^2) both than in hemi disturbed (3,8±0,4 thous. ind./m^2) and undisturbed (3,2±0,5 thous. ind./m^2), but the biomass of communities is equal in all kind of sites (26±2 g/m^2). Hemi disturbed and undisturbed sites were equal both in total community production (145±37 and 131±20 g/m^2 per year) role of functional feeding groups (*predators – 28±1%, collector-gatherers – 35±4%, shredders – 16±1%*) in it. In disturbed sites increased total productions nearly in two times (354±80 g/m^2 per year) and main role in this process play *collector-gatherers (50±2%)* and role of predators and shredders declined in 2-4 times (15±1% and 4±1%). Part of crenophilous taxa was different (p<0,05) in all three groups of sites – disturbed (16,7±0,7%), hemi disturbed (26,0±1,4%), undisturbed (35,0±2,6%) and could be recommended as criterion for spring monitoring.

36-O   Springs online - a geocollaborative approach for archiving, sharing, and reporting of information about springs ecosystem ecology.   *Jeri Ledbetter[1], Lawrence Stevens[1], Benjamin Brandt[2], Abraham Springer[3]*

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Springs—where groundwater emerges from the Earth's surface—are the most biologically diverse ecosystems. Despite their usually small size, springs are biodiversity hotspots, supporting thousands of endangered, rare, and endemic species of plants, invertebrates, fish, amphibians, and other vertebrates. Indigenous cultures regard springs as sacred, using them for medicinal and ceremonial purposes, education of Tribal youth, and as sources of domestic water. Many farms, ranches, towns, and reservations rely on springs for high-quality water supplies.Yet around the world, the loss of springs habitat has become a major but unrecognized environmental crisis for three primary reasons. 1) Information is not available—existing geographic and ecohydrological information on springs is minimal, fragmented, and largely unavailable to researchers, land managers, non-governmental organizations, and the public. 2) Research and conservation efforts are insufficient—enormous attention and funding is devoted to improving management of wetlands and streams, failing to recognize that springs provide baseflow for nearly every major temperate and tropical river system from the Amazon to the Nile. 3) Protection is inadequate—more than 90% of springs have been degraded or lost through poor stewardship, and nearly 20% of seafloor springs are threatened by mining. Sensitive indicators of climate change, springs are inadequately protected, poorly understood, and overlooked in conservation and research. We founded the Springs Stewardship Institute (SSI) to provide guidance, tools, education, and technical support to land managers, researchers, conservation organizations, Tribes, industry, and the public. Particularly in arid environments, where the availability of fresh water is a great concern, the use of springs can be balanced with sustainable ecological integrity. If the source aquifer is intact, springs are surprisingly resilient, and restoration can be relatively inexpensive. Our efforts link science, advocacy, policy, and education to seek practical, point-source conservation solutions that are ecologically and socially sustainable.

SSI presents online tools to guide springs stewards, including our Springs Online database at http://springsdata.org/ to store and share information on springs flora, fauna, water quality, flow, geology, geomorphology, and human influences. This information is used to conduct ecosystem assessment, management guidance, and determine the potential impacts of climate change. Using a MySQL database and a user-friendly interface, we currently have information on 89,159 springs and 12,365 inventories, and we serve 312 users. Although most information is from the United States, the database is designed to accept information worldwide and contains springs data for Canada, Central America, and Europe. We are expanding our network of partners who are conducting springs inventories using our protocols and contributing data.

36-O   Algal and cyanobacterial diversity in springs of the Konjuh Mountain (Dinaric Alps, Bosnia and Herzegovina).

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We studied algal communities in 20 springs located on carbonate and ophiolitic geological substratum in the Konjuh Mountain (north-eastern Bosnia and Herzegovina) throughout 2013. The objectives of the study were: to explore algal and cyanobacterial biodiversity in crenic habitats (including the rarely investigated springs on ophiolites), to analyze the influence of the geological substratum and of the physical and chemical determinants, as well as to assess the trophic and ecological status of these spring habitats. Overall 196 samples were collected from the 20 springs studied, in which 234 taxa were identified. Diatoms (187 taxa) and cyanobacteria (34 taxa) were the most species-rich groups. The number of algae and cyanobacteria species per sample ranged from 5 to 47, and per spring from 46 to 76. The most abundant species were *Achnanthidium minutissimum, Planothidium lanceolatum, Amphora pediculus*, *Meridion circulare*, *Cocconeis lineata, Cocconeis pseudolineata, Gomphonema micropus, Cocconeis euglypta, Odontidium mesodon* (diatoms) and *Tapinothrix varians* (cyanobacterium). The genera with the highest number of taxa, all belonging to diatoms with the exception of the cyanobacterial genus *Phormidium*, were *Gomphonema* (17), *Nitzschia* (16), *Navicula* (12), *Achnanthidium* (11), *Phormidium* (9), and *Cymbella* (8). The average value of the Shannon-Wiener diversity Index was 1.75. The largest number of diatoms were alkaliphilic and circumneutral. A large number of species in common (110) suggests that there are less differences in the structure of algal communities between carbonates and ultramaphites (the present study) than between ultramaphites (this study) and other types of siliceous substrata (e.g.,

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granite, rhyolite; algal community composition data obtained from the literature). Ordination multivariate statistical methods based on relative abundance allowed to identify six groups of springs along gradients that were mainly correlated to geological substratum, calcium and magnesium, discharge and current velocity, nitrates, alkalinity, and conductivity. For springs on carbonate and ophiolitic geological substratum characteristic algal species were distinguished by the IndVal analysis. The values of the Rott Trophic Index were high, due to the dominance of highly competitive meso- and eutraphentic algal species. Spring habitats of the Konjuh Mountain are affected by strong anthropogenic impacts (e.g., water abstraction, trampling by cattle, deforestation, road infrastructure), and most of them show a disturbed ecological status.

36-O   Environmental variability and its influence on macroinvertebrate assemblages of alpine springs.

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Springs are ecotones at the interface between groundwater and surface water, which are inhabited by partly highly adapted organisms. In low mountain ranges they are mainly fed by deep groundwater and drain large catchment areas. At high altitudes catchment areas are naturally smaller and springs are mostly fed by surface-near aquifers. Moreover, snow and permafrost meltwater may additionally influence the environmental conditions in the springs. In this study we examined springs in the Bernese Alps, Switzerland. The water temperature and the solar radiation were continuously monitored, additional environmental parameters such as the electrical conductivity were measured, and a quantitative sampling of the macroinvertebrate assemblages of the uppermost parts of the springs was conducted three times during June 2010 and July 2011. We hypothesized (a) that the variability of the water temperature and other physico-chemical parameters is higher in springs at high elevation than in springs at lower altitudinal ranges and (b) that the decrease in "environmental stability" influences the distribution of crenobiontic and crenophilous taxa. The analysis of the water temperature revealed a significant decrease of the mean water temperature and the variance of the water temperature with altitude. Springs at lower altitudes exhibited higher temperature amplitudes. The electrical conductivity showed a high variability in the springs at high altitudes indicating an influence of snow and permafrost meltwater. Mean electrical conductivity and water temperature had a significant influence on the macroinvertebrate assemblages. Moreover, the duration of the snow cover seems to be important. The percentage of alpine species not restricted to springs significantly increased with altitude, whereas the percentage of spring specialists did not change. Overall, the physico-chemistry of the springs at high altitudes may be harsher, but also more stable. This is favoring alpine taxa, which are adapted to constantly cold water-temperatures, and not the spring-specialists.

36-O   The influence of temperature on the longitudinal zonation of alpine spring systems and their invertebrates.   *Lucas Blattner, Stefanie Von Fumetti*

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It is common knowledge that invertebrate communities change along a stream. Different sections provide different environmental conditions and harbour characteristic species assemblages. Especially springs differ from their subsequent sections. They are considered as stable environments providing oligotrophic and, particularly in the Alps, relatively cold habitats. Due to climatic changes spring organisms, e.g. water mites (Acari: Hydrachnidia), are considered as endangered because of their habitat specificity. Water temperature is one of the most discussed abiotic parameter influencing species occurrence. However, there is evidence that temperature is not the only factor that determines the presence of certain taxa in headwaters. In this study, the influence of the water temperature in eucrenal, hypocrenal and epirhithral sections on freshwater invertebrates was studied. Data loggers were used to measure temperature stability during a nine month period. Further, environmental parameters such as pH, electrical conductivity and substrate composition were investigated. In each section the meio- and macroinvertebrates were sampled quantitatively by using a small surber sampler and qualitatively by using a hand net. An adjusted 200 µm mesh was chosen to include water mites. Results show that temperature changes significantly, whereas the other abiotic parameters show little differences between the three stream sections. Temperature stability seems to increase towards the eucrenal, which indicates groundwater dependency in contrast to the environmentally affected downstream sections. Faunistic investigations give evidence that species communities show little differences along the investigated stream sections. In combination with the significant temperature changes, this leads to the assumption that species,

which are considered as crenobionts, tend to be less temperature sensitive than expected. Nonetheless, temperature increase could affect various environmental prerequisites such as discharge and therefore substrate composition. Such habitat shifts induce a change of ecological niches and therefore may lead to a shift in specialized species communities.

36-O   The benefit of data loggers for hydro-ecological monitoring of alpine springs.   *Fabian Wigger, Peter Nagel, Stefanie von Fumetti*

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In remote alpine areas it is elaborate and difficult to get fine-grained environmental data for the hydro-ecological analyses of natural springs. This is, however, of special importance for the analysis of flow-pathways and the relationships of climatic parameters such as precipitation and the hydro-morphological parameters in springs. In this study we investigated ten remote springs situated in the Bernese Alps, Switzerland, at different altitudinal levels. We used data loggers for gaining fine-grained data of the water temperature, the electrical conductivity, the oxygen saturation and the radiation during 10 months. Other meteorological data such as precipitation and air temperature were taken from the nearest meteorological station. The aim of the study was to analyse the reaction time of the springs on meteorological changes and events such as extreme rainfall or drought periods. We compared, for example, the trend of the water temperature of the springs and the air temperature with a one hour resolution. An average delayed reaction of the water temperature to changes of the air temperature can give information about the hydraulic residence time in the aquifer. To statistically evaluate such trends in our data we used cross-correlation analyses. Thereby two parameters or signals were compared with each other. First results indicate an altitudinal dependency of the hydraulic residence time: springs at high elevation have a longer reaction time than the springs at lower altitudes. As the loggers also measured the radiation we can reconstruct if the snow cover, which interrupts the radiation at the springs under the snow, influences the reaction time. Data loggers and the statistical interpretation of their data can lead to an increase of information in spring research. They have the advantage that they are noninvasive, their costs are low and they store large data volumes. As these springs are faunistically well investigated we want to detect in a further step, if the faunistic composition of the springs differs according to the detected flow regime and reaction time.

36-P   Diatom communities from thermal springs in NW Iberian peninsula.   *Cristina Delgado Núñez [1, 2, 3], Maria João Feio[2], Isabel Pardo[3], Salomé F.P. de Almeida[1]*

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The study of hot springs such unique environments offers an excellent opportunity to investigate diatoms' thermal tolerances and their ecological adaptations. We studied 14 thermal springs in the NW of the Iberian Peninsula (Spain and Portugal) during summer 2015. Diatoms were present in seven springs covering a thermal gradient between 20.9 and 42.4 ºC conductivity up to 557.5 μScm^{-1}, pH between 6.4 to 8.3 and dissolved oxygen between 18.1 – 160.0%. Diatoms were absent form very hot springs (above 42.4 ºC). Diatoms samples (n=17) allowed the separation of thermal springs in three groups: 1) <25ºC (n = 6), 2) 25-35 ºC (n = 7) and 3) >35 ºC (n = 4). Shannon-Wiener's diversity index (H') was calculated with the Omnidia program v. 5.5 and diatom data was analysed with the Primer + Permanova v. 6 software.
The PERMANOVA main test on no transformed diatom data showed that differences in communities found at the three temperatures were close to be significant (PseudoF = 1.569; p = 0.056). These pairwise tests showed that the significant differences were between the samples below 25ºC and above 35ºC. The Canonical analysis of principal coordinates (CAP) confirmed that diatom communities were well segregated by temperature and that sites can be predicted into their own temperature groups by their community (71% correctly attributed). The group with a higher similarity was the highest temperature (>35ºC) with a 34.3% probability. Our results indicate the high specificity of the few species able to tolerate high temperatures, not able to survive in colder temperatures. When comparing the temperature groups results showed that *Achnanthidium exiguum* and *Encyonema* sp.1. showed preferences for higher temperatures and *Pinnularia* sp., *Caloneis* sp. and *Gomphonema* sp. 1 were only found in higher temperatures. *D. confervacea* and *Achnanthidium catenatum* prefer intermediate high temperatures. *Navicula angusta*, *N. veneta*, *Nitzschia amphibia*, and *Staurosira construens* appeared at intermediate temperatures (25-35ºC). The diatom association characterising the

cold group were: *A. subhudsonis*, *A. exilis*, *Planothidium lanceolatum*, *Amphora pediculus*, *Fragilaria crotonensis*, *Ulnaria biceps*, *Cocconeis pseudolineata*, *Encyonema minutum* and *Nitzschia dissipata.* Highest diversity corresponded at sites located at the confluence of the hot springs with the Miño river (H' = 4.1). On the contrary, samples with the lowest diversity were other springs with little influence of the rivers (H' = 0.1 and 0.6).

In this study we have identified differences in the thermal tolerances of diatom species, and on the existence of particular diatom assemblages at various temperatures and ranges. Or results support the validity of the use of species thermal tolerances as a proxy to assess the prediction of potential changes in species composition in streams under climate change scenarios, as well as to establish a baseline for hot springs biodiversity conservation.

36-P   Epiphytic and epilithic diatom assemblages in mediterranean karst springs: a case study from Sardinia (Italy).   *Giuseppina Grazia Lai [1] - Luc Ector [2] - Bachisio Mario Padedda [1] - Carlos Eduardo Wetzel [2] - Nicola Sechi [1] - Antonella Lugliè [1]*

University of Sassari, Sassari, Italy [1] - Institute of Science And Technology (LIST), Environmental Research And Innovation Department (ERIN), Research Center, Belvaux, Luxembourg [2]

Karst springs are strategic water sources and potential hotspots of biodiversity in the Mediterranean region. They are poorly studied from the ecological point of view, and their biocenoses, in particular the algal communities, are mostly unknown in Sardinia, the second largest island in the Mediterranean Sea. Between 2010 and 2015, we carried out a survey at Sa Vena, the smallest spring of the Su Gologone, the most important karst system of Sardinia. Sa Vena is a rheocrene spring captured for drinking purpose and located in the Supramonte, a Site of Community Importance and a Special Protection Area belonging to the Natura 2000 network. The aims were 1) to characterize the species composition of epiphytic and epilithic diatom assemblages and 2) to describe their relationships with environmental variables. A complete floristic list of 148 diatom species belonging to 54 genera was compiled for the spring, including diatom taxa recorded with very few specimens and thus not present in the counts (e.g., *Achnanthes coarctata*, *Achnanthes inflata*, *Achnanthidium bioretii*, *Asterionella formosa*, *Caloneis amphisbaena*, *Gomphonema angustius*, *Halamphora paraveneta*, *Neidium dubium*, *Nitzschia perminuta*, *Nitzschia vitrea*, *Surirella angusta*, *Tabellaria flocculosa*). The epiphytic diatom assemblages (80 diatom species, 30 genera) were mainly dominated by *Achnanthidium subatomus*, *Meridion circulare* and *Planothidium lanceolatum* whereas the epilithic diatom samples (75 diatom species, 32 genera) were mainly dominated by *Achnanthidium minutissimum*, *Achnanthidium subatomus* and *Amphora pediculus*. Epiphytic and epilithic assemblages showed significant differences according to non-metric multidimensional scaling (MDS) ordination model (ANOSIM test: global R: 0.913, p = 0.2%). Redundancy analysis (RDA) was performed on the epiphytic and epilithic diatom taxa with relative abundance > 3%. RDA on epiphytic assemblages (axis 1: 53.8% and axis 2: 23.7% of variance) indicated temperature, pH, conductivity and nitrates as the most important variables for the species composition whereas, on epilithic assemblages (axis 1: 49.7% and axis 2: 27.1% of variance), they were phosphorus, magnesium ion, nitrates and total suspended solids. The high number of species reflect the heterogeneity of microhabitats of the spring due to the high degree of naturalness of the territory and suggests the importance of preserving and properly handle this environment.

36-P   Endangered molluscs of European fens: current data and conservation of glacial relics.

Veronika Horsáková, Michal Horsák

Department of Botany and Zoology, Faculty of Science, Masaryk University, Brno, Czech Republic

Mire habitats serve as an important carbon storage and refugia for rare and relict species, being at the same time seriously threatened by the ongoing environmental changes. In our research we focus on fens, i.e. groundwater-fed mires, and their mollusc fauna. In central Europe, fens are represented by small and isolated remnants of formerly larger fen areas and hence their mollusc diversity has long been overlooked. However, fens harbour exceptionally rich mollusc assemblages including many endangered fen specialists. All the four European Annex II *Vertigo* species are fen inhabitants with two of them, namely *V. genesii* and *V. geyeri*, being entirely restricted to fens. Recently, we found new isolated occurrences of these species as well as of the northern European *V. lilljeborgi*. According to the fossil record these species are regarded as glacial relics and their occurrence gives evidence about the ancient origin and historical continuity of fens throughout the Holocene. Conservation of all preserved fens is thus of crucial importance, with

respect to the genetic diversity and phylogenetic history of these species and maintenance of the habitats with species-rich mollusc fauna.

36-P   Spring fen mollusc and plant communities of the western Carpathian Mts: ecology and paleoecology.   _Michal Horsák, Michal Hájek, Petra Hájková_

Department of Botany and Zoology, Masaryk University, Brno, Czech Republic

Fens are nutrient-limited wetlands fed by mineral-rich ground waters, with a tight response of species richness and composition to the water chemistry. Fen habitats support species rich assemblages of both plants and molluscs, including many globally threatened habitat specialists and glacial relicts. Species richness generally increases towards alkaline fens, with a strong response observed in molluscs. While a clear species turnover is characteristic for plants, molluscs express the nested subsets along the calcium gradient. As fens accumulate organic sediments with a rich fossil material, an exact dating and the reconstruction of their development are easily possible. The Late Glacial origin of the oldest temperate fens maintains the existence of many glacial relicts, surviving there in isolated populations. The occurrence and number of these relicts was found to be associated with the age of fens and/or a continuous presence of suitable fens during the Holocene. We found that the number of habitat specialists in these insular systems increases with habitat age and/or area, with habitat age becoming more important as species dispersal ability decreases. Currently supported by P505/16-03881S.

37. PREDICTIVE LIMNOLOGY REVISITED: ROB PETERS' LEGACY AFTER 20 YEARS

37-O   Freshwater challenges: are limnologist's answers mismatched with society questions?

Antonella Cattaneo [1] *- Yves Prairie* [2]

Dep. Biology, Université De Montréal, Montreal, Canada [1] *- Dep. Biology, Uqam, Montreal, Canada* [2]

Two decades ago, Rob Peters championed predictive limnology as a solution to the mismatch between societal demands and limnologists' responses. We revisit these statements in 2016 when freshwater short supply and compromised quality pose increasing challenges to health, industry, and nature. First, we examine through the analysis of major scientific publications the fortune of predictive limnology in the course of the last twenty years. As this approach flourished and generated multiple citations or it has been somewhat neglected in view of catchy new trends? We then compare the main pressing questions presently posed by water managers and public at large with the topics most frequently addressed by limnological papers. The mismatch is still dramatically evident. In Rob's words: "We should make the best and most effective use of our science to protect and to cherish the world around us". We hope to incite a discussion of ways to make limnology relevant to the freshwater crisis.

37-O   Robert H. Peters, the ways to theory, scientific revolutions, knowledge typology, the art of the soluble, and predictive ecology.   *John Downing*

Minnesota Sea Grant Program / Large Lakes Observatory, University of Minnesota Duluth, Duluth, United States

Rob Peters died while working on fleshing out his ideas about efficient ways toward scientific progress. Rob maintained that scientists must address the most pressing environmental problems and should do so by asking soluble and tractable questions, building theory from observed data, using empirical theory as a precursor to explanatory theory, and by using rigorous hypothesis testing to distinguish among competing theories. According to limnologists, the most pressing water problems will not change in importance over the next decades because limnologists will make little progress in solving them. I will review limnological problems and attribute the lack of progress to causes linked to Peters' vision of scientific failure. Next, I will review Peters' 1995 vision of the elements of predictive limnology and ecology as a hierarchy of theories from individuals to populations to ecosystems to biomes to global envirional science. I will show empirical analyses the demonstrate that the science done aquatic scientists today does little to advance us toward solution of the world's pressing water problems and will sketch the approach that Rob might have prescribed to realign our science with the global problems that limnologists need to solve.

37-O   Common misconceptions about doing (and reviewing) ecological science.   *David J. Currie*

Biology Department, University of Ottawa, Ottawa, Canada

Peters' (1991) *Critique for Ecology* began with the argument that some ways of doing science are more effective than others. In that spirit, I propose that several common misconceptions have hindered the progress of ecological science in recent decades, both in the planning and execution of science, and as science undergoes peer-evaluation.   My main premise is the same as Peters': the goal of science is predictive ability. Predictive ability provides the main utility of science to society, the means of testing hypotheses, and the empirical evidence that science actually has a grasp on reality. Common misconceptions in recent ecological literature include the notions that: 1) understanding mechanisms is the primary goal of ecology; 2) correlative evidence is necessarily weak; 3) controlled experiments are the strongest way to test hypotheses about nature; 4) the complexity of ecological systems means that refutation of ecological hypotheses is generally hopeless; 5) supporting evidence increases the probability that a hypothesis is true; 6) fitting a statistical model represents a test of its underlying hypotheses; and 7) the output of simulation models represents statements about nature. I will argue that these misconceptions are regularly found in some of the most prominent ecological literature. They often occur in peer reviews of macroecological studies (Peters' predictive ecology by another name). I submit that these notions have favored an encyclopedist accumulation of facts, at the expense of hypothesis refutation and development of predictive theory.   Ecologists are generally inspired by Darwin's contemplation of the

"tangled bank"; I propose that we should be equally inspired by Newton's wish "to derive two or three general principles ... and afterwards to tell us how the properties and actions of all corporeal things follow....".

37-O   Using the past to better predict the future: paleolimnological perspectives on ecosystem change.   _John Smol_ [1] - _Jules Blais_ [2]

Pearl, Queen's University, Kingston, Canada [1] - _Department of Biology, University of Ottawa, Ottawa, Canada_ [2]

Rob Peters had a profound influence on many limnologists. Although he was an early critic of paleolimnology, he later became a proponent, yet continued to cast a critical eye on methodologies and approaches. As he once wrote "… we hone our theories and research until they are as keen and sharp as they may be. The whetstone against which we sharpen our tools is criticism." Rob recognized that one of the greatest challenges faced by limnologists and water quality managers is in the use of appropriate spatial and temporal scales. Due to the general lack of reliable long-term limnological data, it is often difficult to study the nature and timing of ecosystem changes, as well as setting realistic background or pre-impact conditions. This presentation will summarize some of our recent paleolimnological work that attempts to use the past to help predict the future, focussing on some of Rob Peters's writings and critiques of limnology. Similar to his mentor, Frank Rigler, Rob advocated for limnologists to search for broad-scale patterns in ecological data. Given that a large number of paleolimnological analyses now exist for many regions, meta-analyses of such profiles can provide important insights on broad-scale ecological patterns. In addition, building on Rob's vision for trans-disciplinary approaches, we summarize some of our ongoing work in developing the field of "paleo-ecotoxicology" as well as ongoing research assessing the effects of multiple stressors on aquatic ecosystems.   As Rob Peters once noted "Limnology is the science of trying to make sense out of nonsense" -- we clearly acknowledge that challenges remain, but by offering the critical third dimension of time to many limnological issues, paleolimnology continues to play an important role in understanding and predicting ecosystem change.

37-O   Ecosystem-size dependence of freshwater carbon cycling.   _Carlos M. Duarte_ [1] - _Yves T. Prairie_ [2] - _John A. Downing_ [3] - _Jonathan J. Cole_ [4] - _William H. McDowell_ [5] - _Lars J. Tramvik_ [6] - _Robert G. Striegl_ [7] - _Pirkko Kortelainen_ [8] - _Jack J. Middelburg_ [9]

King Abdullah University of Science and Technology (KAUST), Thuwal, Saudi Arabia [1] - _Université Du Quebec A Montreal, Montreal, Canada_ [2] - _University of Duluth, Duluth, United States_ [3] - _Institute of Ecosystem Studies, Milbrook, United States_ [4] - _University of New Hampshire, Durban, United States_ [5] - _Uppsala University, Uppsala, Sweden_ [6] - _USGS, Boulder, United States_ [7] - _Finnish Environment Institute, Helsimki, Finland_ [8] - _Utrecht University, Utrecht, Netherlands_ [9]

Lakes and river systems are intense sites of carbon cycling in the biosphere, expressed in terms of CO_2 exchange with the atmosphere and organic carbon burial rates. However, carbon fluxes vary orders of magnitude within these systems and, thus far, there is limite understanding of the drives of these changes, which remain a major source of uncertainty in scaling up the contribution of freshwater ecosystems to global carbon fluxes. A possible strategy to scale up these fluxes rests in coupling the size-dependence of lake and river ecosystems, which have been shown to follow a Pareto distribution, with size-dependence carbon fluxes. Lake and river size are strong predictors of many relevant limnological processes and, thus, we hypothesize here that carbon fluxes can also be predicted from ecosystem size, thereby enabling the scaling up of carbon fluxes in freshwater ecosystems to the global scale.

37-O   Contrasting responses of freshwater and marine photosynthetic organisms to UV-B radiation.
Peng Jin , Carlos M. Duarte, Susana Agusti

Red Sea Research Center, King Abdullah University of Science and Technology, Thuwa

Ultraviolet-B (UVB) radiation is a global stressor that has profound impacts on freshwater and marine ecosystem. Here, we perform a meta-analysis based on 4995 experimental data compiled from the literature to quantify and compare the magnitude of the effect of UVB radiation on aquatic photosynthetic organisms. We found data from both marine (n=893) and freshwater macroalgae, and from marine (n=1087) and freshwater (2889) microalgae, but there were fewer

experimental data testing sensitivity of aquatic angiosperms (solely from marine systems). Most studies used natural solar radiation removing the UVB radiation to compare with responses under total solar radiation spectra (85%), against those increasing UVB radiation by using mostly artificial lamps (15%). Macroalgae were more resistant than microalgae to UVB radiation and within marine macroalgae, Phaeophyta was significantly more resistant than Chlorophyta and Rhodophyta. Freshwater Charophyta showed significantly lower sensitivity. Diatoms, were significantly more sensitive to UVB than other microalgae, and freshwater Chlorophyta were significantly more resistant. Freshwater Macroalgae were significantly more resistance than marine (P<0.0001) when exposed to increased UV-B radiation, but no differences were found when reducing the natural UVB radiation. Similarly, Freshwater microalgae were significantly more resistance than marine. Lastly, the vulnerability of microalgae to UVB radiation was size-dependent, with small-celled species experiencing much steeper impacts for a given UVB increment than large-celled species do.

37-O   Sustaining aquatic ecosystems in changing world: prediction and resilience.   *Michael Pace*

Department of Environmental Sciences, University of Virginia, Charlottesville, Virginia, United States

Robert Peters challenged ecologists to develop a predictive science, and he held up empirical approaches in limnology as a model for progress. The need for a predictive science remains especially as limnology confronts large scale environmental change. For example, the thermal and hydrological dynamics of inland waters are being altered by climate change. Other forces such as the globalization of trade cause species invasions and depletions contributing to rapid shifts in communities within inland waters. The impacts of these environmental changes on aquatic ecosystems may be predictable in many cases. Current research provides examples of: 1) ecological forecasts, 2) early warning statistics that signal potential for abrupt change in aquatic ecosystems. These largely empirical endeavors are consistent with Peter's vision and increased research on predictive approaches is warranted. However, there will be limits to predicting the responses of inland waters to complex environmental and anthropogenic drivers. Other approaches to coping with environmental change include enhancing ecosystem resilience to reduce the possibility of crossing unwanted thresholds. Peters would likely argue that resilience, similar to many ecological concepts, is too vague and general a notion to be useful. A counter to this concern is through the implementation of management programs that set goals, measure ecosystem attributes, and react to changing conditions. Such programs can operationalize the resilience approach to help sustain valuable aquatic ecosystems. Hence, in addition to predictions, forecasts, and empirical warnings, advances are needed in managing aquatic ecosystems in order to foster resilience and cope with the growing forces of environmental change.

37-O   Empirical limnology of urban ponds: just like lakes?   *Frances Pick, Mary Ann Perron, Kasandra Labonté, Muriel Rolon Merette*

University of Ottawa, Department of Biology, Ottawa, Canada

Urban ponds are multiplying in North America as cities expand. They are primarily designed for flood control and to mitigate downstream pollution from runoff in new residential and industrial areas. However, they can also provide valuable greenspace and "bluescape" in cities. For limnologists they represent novel, quasi- experimental, ecosystems where hydrological and biogeochemical budgets can be readily determined. The City of Ottawa (capital of Canada) has over 100 such ponds of varying in age and size. Taking an empirical cross- system approach, we tested the role of classical drivers of aquatic ecosystems: total phosphorus (TP) was a strong predictor of algal biomass in ponds but the percent imperviousness of the catchment was also a significant predictor of algal biomass, likely because greater imperviousness leads to higher TP loading. At the within-pond scale water renewal rates become an important factor in explaining the seasonal variation in algal biomass and primary productivity rates which, at times, approach the theoretical maximum for aquatic ecosystems. These urban ponds are metabolic cauldrons that also have the potential to support similar species richness (albeit of different composition) as natural pond systems thus providing some biodiversity in cities.

37-O   Simple ecological models by evolutionary computation proof Peters' vision right.   *Friedrich Recknagel*

University of Adelaide, School of Biological Sciences, Adelaide, Australia

Robert H. Peters argued in 1986 that prediction in limnology requires simple, operational and quantitative models (Peters 1986). In contrast, deterministic models are complex but rationally bounded and opaque, describing ecological processes by algebraic equations based on Michaelis-Menten-type kinetics and empirical relations (Rigler and Peters 1995), that therefore rarely justify the term deterministic (Flynn et al. 2015).

John Holland postulated in 1986 two cognitive principles of evolutionary computation that proof to be highly relevant for studying ecological systems (Holland 1986): 1 'generative creation' that corresponds with the evolving nature of ecosystems, and 2 'choices over open-ended possibilities' that suit well the complex stochastic appearances of ecosystems.

When applied to complex ecological patterns, evolutionary computation develops simple inferential models by multiple nonlinear regression selected from multiple alternative models based on generality, accuracy and precision as envisaged by Peters (1986).

Simple models as understood by Peters (1986) were empirical and provided little 'ecological insight' or 'causal understanding'. Simple models discovered by evolutionary computation succeed this limitation by quantifying tipping points and ecological interrelationships for forecasted ecological entities (Recknagel et al. 2014; Recknagel et al. 2016), and therefore may even 'enhance our insights in mechanisms that are difficult to grasp intuitively' (Scheffer and Beets 1994).

The operational, predictive and elucidatory capabilities of simple models by evolutionary computation are demonstrated by real-time forecasting of outbreaks of population density of cyanobacteria in Lake Wivenhoe (Australia) and of high concentrations of cyanotoxins in Vaal Dam (South Africa).

37-O   Investigating the effect of internal phosphorus loading on cyanobacteria: hypotheses & case studies.   *Gertrud Nurnberg*

Freshwater Research, Freshwater Research, Baysville, Canada

I investigated two hypothesis. (A) Cyanobacteria blooms can be caused by phosphorus (P) released from lake bottom sediments, and (B) the recent increases in such blooms are often caused by increases in internal P loading.

The limnological (mechanistic) reasoning behind these hypotheses include effects of climatic change (hypolimnetic temperature increases and lengthening of stratification and therefore increased hypoxia) and release of previous P inputs that have accumulated in the sediments as "legacy" P (especially in reservoirs). In addition there is a more comprehensive understanding of sediments that are active in releasing P, including bottom sediments in shallow, oligo- or polymictic lakes overlain by oxic water.

Quantitative and verifiable (because testable) aspects that support Hypothesis A are presented in case studies and include

1 Seasonal increases (from summer to late fall) of correlated TP and chlorophyll (indicating cyanobacteria) concentrations in many lakes of different sizes, including mesotrophic oligomictic lakes during a conspicuous lack of external loading.

2 Relationships between annual hypoxia (related to internal loading) and cyanobacterial biomass (e.g., eutrophic Lake Winnipeg, Manitoba, 24 000 km^2, and mesotrophic Lake Simcoe, Ontario, 722 km^2) or just soluble reactive P and chlorophyll concentration (Lake Erie Central Basin and northern shore) in large lakes.

3 Correlations between cyanobacterial bloom indicators and decreased flows in rivers and reservoirs (with the assumption that decreased flow encourages internal loading).

4 Reduction of cyanobacteria as a result of internal load abatement (case studies of restoration by P adsorbing materials, including aluminum compounds or lanthanum amended clay, Phoslock, as well as hypolimnetic withdrawal.)

Quantitative aspects that support Hypothesis B include

5 Relationships between annual hypoxia (Snake River, Idaho, reservoir) or a cyanobacterial bloom indicator (Thames River, Ontario) and climatic indices that in turn are correlated to the variability of seasonal flows.

Results of such predictive approaches are often downplayed as mere circumstantial evidence without any confirmation of causality. But the occurrence of multiple correlations between internal loading and cyanobacterial blooms in different limnological systems and obtained by a variety of approaches suggests causality.

In a practical context, the potential corroboration of a link between internal load and cyanobacterial blooms informs lake management: any treatment that diminishes internal loading from the sediment would benefit cyanobacterial bloom abatement.

37-O   Research of R.A. Vollenweider in the Istituto Italiano di Idrobiologia as a contribute to the development of watershed phosphorus load - lake trophic state models.   *Rosario Mosello, Michela Rogora, Aldo Marchetto, Massimiliano Cremona*

CNR, Institute of Ecosystem Study, Verbania Pallanza, Italy

Richard A. Vollenweider (Zürich, 1922–Burlington, 2007) developed one of the first and probably the most used predictive model of lake eutrophication, relating nutrient loading to the biological response.

In this presentation, we follow his early career to identify the cultural environment that allow him to develop his model. After getting his Ph. D. in Biology in the University of Zürich (1951), he spent several years studying the limnology of Italian lakes at the Istituto Italiano di Idrobiologia Dott. Marco De Marchi in Verbania Pallanza (now the Institute of Ecosystem Study of the National Research Council of Italy), where he was awarded a study grant from 1954 to 1955, later being engaged as a contract researcher from 1959 to 1966. He considered very different aspects of limnological research, such as the regional hydrochemistry of subalpine lakes in relation to the geo-lithology of the watersheds, the mixing pattern of the deep lakes of the area (lakes Maggiore, Como, Lugano), the impact of River Toce flood events on the distribution and sedimentation of particulate matter in Lake Maggiore, phytoplankton primary production measured using the light and dark bottle technique and, later, with the ^{14}C method of Steemann-Nielsen. Primary production of the two lakes Maggiore and Mergozzo were compared, and experiments of nutrient enrichment of water performed. Other studies, all of them important from a limnological standpoint, involved a diverse range of topics; for example, laboratory experiments on the vitamin B12 requirements of *Fragilaria crotonensis* and composition of new media for algal cultures.

These activities were performed in strict contact and agreement with Italian researchers, such as the director of the Institute Vittorio Tonolli, Oscar Ravera, Carlo Saraceni, Luigi Provasoli, and with foreign limnologist, frequently present in the Institute. The high quality and number of his publications testify to his tireless activity; 11 of them were published in the Memorie dell'Istituto Italiano di Idrobiologia (since 1999 published under the title of Journal of Limnology).

In 1996 he got from the Organization for the Economic Cooperation and Development (OECD) a contract for the study of the causes of freshwater eutrophication. In this task he used all the experience he had accumulated and conspicuous available literature to produce in 1968 a work, where the role of phosphorus in determining the increase of lake trophic status was recognized and a preliminary predictive model linking phosphorus load to the lake trophy was proposed. This approach was fertile of developments and signed a remarkable progress in the freshwater studies and management.

The presentation will discuss the different aspects which determined the approach of R.A. Vollenweider to this topic, considering the status of research on the theme, and his personal experiences, based on the papers he produced and on documents of the historical archive of the Institute.

37-O   Improving our predictions of cyanobacteria occurrence.   *Alessandra Giani [1] - Zofia E. Taranu [2] - Marcele Laux [1] - Irene Gregory-Eaves [3]*

Departamento de Botanica, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil [1] - Département de Sciences Biologiques, Université De Montréal, Montreal, Canada [2] - Department of Biology, Mcgill University, Montreal, Canada [3]

There is growing evidence that cyanobacterial blooms are becoming more common in different parts of the world; within this context, predictive cyanobacteria models have an essential part in lake management. Several models have been successfully used in temperate systems to describe the main drivers of cyanobacterial blooms, but relatively less work has been conducted in the tropics. To address this gap, we evaluated how different models could be applied to temperate and tropical systems. For this purpose, we analyzed data from six Brazilian reservoirs and from five Canadian lakes, and, using a combination of variance partitioning and regression tree analyses, we identified the common versus unique drivers of cyanobacteria biomass in both regions.

We will also conducted metagenomic analyses in one reservoir, to open the discussion on how this new technique may improve our ability to predict processes in aquatic communities. Our results showed that some predictors, like total phosphorous, were common to all water bodies, but we also observed that more parameters were needed to explain the cyanobacteria biomass in more variable systems such as the reservoirs. Among the temperate lakes, we observed similar slopes describing the relationships between cyanobacteria biomass and phosphorus. However, in the tropical

systems, we saw a much greater degree of heterogeneity, and needed additional parameters to explain variation in cyanobacteria biomass. Specifically, phosphorus was the most important driver in tropical reservoirs with elevated cyanobacteria biomass, whereas climate and human-mediated variables (water residence, precipitation, and surface water temperature) were important in sites with relatively lower cyanobacteria biomass. In a second step, we performed metagenomic analyses in one reservoir. Metagenomic surveys are powerful in their ability to link functional and phylogenetic information of microbial communities to the chemical, physical, biological parameters that describe an environment. Knowledge about the potential genetic profile of the environment will provide a stronger mechanistic basis for the models. The metagenomic dataset showed that the overall functional profile was maintained during the entire development of a bloom, however, there was an increase in microdiversity once cyanobacteria dominance became more intense, when more strains seemed to contribute to the genetic pool by complementing and sharing functions, resulting in higher genetic diversity. Taken together, these results suggest that multi-region syntheses can help identify drivers that predict broad-scale patterns of cyanobacteria biomass, and that the genetic functional composition derived from metagenomics could serve as a complementary approach to model additional fine-scale ecological processes in highly variable systems.

37-O   Use of empirical predictions – from water policy to management of the lake.   *Ilkka Sammalkorpi*

Finnish Environment Institute, Freshwater Centre, Helsinki, Finland

Empirical predictions derived from large datasets of lakes have been of crucial importance in the 20th century water policy and implementation of their conclusion of the necessity to reduce the external nutrient loading to lakes has had a remarkable societal and ecological impact. Reductionistic predictions using nutrients, mainly total phosphorus (TP) as the independent variable have been published in addition to chlorophyll-a (Chl-a), also for e.g. fish biomass and waterfowl. Authors of articles presenting predictions with high R^2 and low P values often see their results useful tools for lake management. However, though many of the predictions are important in policy recommendations, their ecological significance in management of a single water body may vary largely even for predictions with high statistical significance. When we descend from the level of average trends of large datasets to a specific water body, the predictions of the dependent variable can vary by an order of magnitude within a certain concentration of TP and the range may include both a target level and values representing e.g. only a moderate status.

   An alternative or complementary view is that high and low, even outlying values are ecologically more informative for management decisions than average predictions. The uppermost and lowest values of biological dependent variables within a certain nutrient level indicate both an undesirable and a favourable outcome of biotic interactions and thus the high scatter of values can be ecological information of a possible achievable level of biotic parameters. The lake specific target of management can be set to the high (transparency, piscivores, waterfowl) or low (phytoplankton, cyprinids) values in the range of empirical predictions.

   I found that comparing the biotic parameters of individual lakes to empirical predictions derived from large datasets, even from TP to higher trophic levels like fish or waterfowl, is a useful tool in decision making of lake management. E.g. a linear increase and positive & significant correlation between TP and Chl-a, TP and biomass of fish removed in lakes restored by biomanipulation or TP and the density of waterfowl represent situations in which the dependent parameter has been released from a limiting biotic factor like grazing, predation or resource competition and, vice versa, increase of these biotic pressures leads to a reverse situation.

38. NATURAL AND ANTHROPOGENIC INFLUENCES ON THE ECOLOGY OF MACROPHYTE BEDS

38-O　Changes in interspecific interactions and community structure following introduction of nonnative elodea canadensis in a species-rich lake macrophyte community.　*Paola Lombardo [1], Marit Mjelde [2], Dag Berge [2]*

Limno Consulting, Rome, Italy [1] - Norwegian Institute For Water Research (NIVA), Oslo, Norway [2]

The North American native *Elodea canadensis* Michx. spread rapidly in (Lake) Steinsfjord, a large, mesotrophic, clear-water, richly vegeted lake in southeastern Norway. Quantitative vegetation surveys were conducted in the initial stages (1979–1980) and subsequent post-peak period (2004) of the *E. canadensis* invasion. Lake-wide species richness remained at >30 taxa, maximum vegetation colonization depth (z_{max}) and water transparency remained at ~6 m, and *E. canadensis* did not change its preferential depth at ~3-3.5 m by 2004. However, *E. canadensis* expanded its depth range to z_{max} and increased significantly its sediment coverage at almost all depths, along with parallel increases in total vegetation coverage, by 2004. Most other species shifted their preferential depths away from *E. canadensis*'s (*Chara globularis*, *Potamogeton crispus*, *P. perfoliatus*) or went (*quasi*) extinct by 2004 (*Najas flexilis*, *Callitriche hermaphroditica*, *P. pusillus*). Close-range aboveground interspecific interactions, analyzed with Lombardo & Mjelde's (2014) $\hat{\alpha}$ index, indicate that *E. canadensis* was initially subordinate to common species (*Myriophyllum alterniflorum*, *P. berchtoldii*) that had remained common by 2004, or tended to dominate over those species that were eventually greatly reduced in the 3-4 m depth interval. Colonization and establishment of *E. canadensis* were apparently favored by space availability at intermediate depths (2–4 m) and hampered by habitat instability and waterfowl grazing in shallow waters. The macrophyte community shifted from a low-density, more diverse assemblage characterized by numerous but relatively loose interspecific interactions in 1979–1980, to a high-density, less diverse assemblage with fewer but stronger interspecific interactions driven by "super-dominant" taxa in 2004. Two distinct assemblages were identified in both sampling periods: a shallow-water (depth <2 m) assemblage dominated by *M. alterniflorum* and a deeper-water assemblage initially codominated by *N. flexilis* and *P. berchtoldii*, and then single-handedly dominated by *E. canadensis*.

38-O　Water primroses (*Ludwigia* spp.) in France: ecology and distribution as new macrophyte weeds on meadows.　J*acques Haury, Valentin Lehericey, Benoît De Boisgelin, Michel Bozec, Julie Coudreuse*

INRA UMR ESE, Agrocampus Ouest / INRA, Rennes, France

The amphibious Onagraceae *Ludwigia peploides* and *L. grandiflora* have been introduced since the beginning of 1830s in South-East France for ornamental purposes in little ponds. These macrophytes have colonized more and more aquatic or wetland sites in France and now they are establishing on meadows, becoming a worrying problem for farmers: less forage, decrease of herb yield, loss of grants by EU and by France.

With an inquiry and site analyses our purposes were to point out *Ludwigia* distribution, and to know the importance of this phenomenon of terrestrial forms both about geographical extent and the problems encountered by stakeholders in managing sites. Then we analyzed some sites to estimate risks or local extension and collected data for Brière marsh to point out invasiveness of *Ludwigia*. On one other site(Grandlieu Lake) with both species coexisting we compared their ecology and adaptation.

Within the 120 responses, only 51 sites possess terrestrial populations of *Ludwigia*: 12 *L. grandiflora*, 8 *L. peploides*, 16 both species, 15 undetermined species. 22 sites concern wet meadows. In most cases, terrestrial forms appeared after 2000, unless in Brière marsh (1994 or 1995).

The water primroses are difficult to remove because they are strongly rooted in soil. Furthermore, scattering of these invasive *Ludwigia* is particularly strong because they disperse by cuttings. The colonized areas are deeply invaded and their important covers limit the development of other plants, which entails a decrease of the biodiversity.

The first step is to prevent colonization, but with high discharge events, the whole flooded area can be colonized, unless some physical barriers can retain cuttings or fruits. In most cases, it is too late to prevent and regulation must be undertaken. Many management practices are cited, without distinction of aquatic or terrestrial ecosystem: the main ones are manual and mechanical pulling, crushing, mowing, cattle grazing, changes in water height, and in some cases

herbicides have been employed. Stakeholders indicated their evaluation of efficacy: few methods are very effective unless pulling. Nowadays, managers in charge of natural areas are often powerless face to this problem.

When both species coexist, *Ludwigia peploides* colonizes wetter habitats than *L. grandiflora*. In Grandlieu site both species had comparable total biomasses per m² around 1.5 kg.m⁻², but underground biomasses of *L. grandiflora* were significantly higher than those of *L. peploides. L. grandiflora* had more leaves, longer internodes and more ramifications than *L. peploides*. Thus we can conclude that *L. grandiflora* is more competitive than *L. peploides* as meadow colonizer.

38-O   Submerged aquatic vegetation in deep lakes: distribution patterns and environmental drivers.

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The aims of our study were to test the hypothesis that submerged aquatic vegetation (SAV) structure in deep lakes is non-random and to investigate the environmental drivers of such communities. We collected data from five deep lakes belonging to the Italian volcanic-lake system (Italy), which is one of the most important reserves of freshwater and macrophyte diversity in the Mediterranean area. A homogenous littoral sector was selected at each lake and a grid based on a net with a 50 m mesh size was generated on a one km-long stretch of coast. Twenty-five sample cells in each sector were then selected at five different predetermined depths (1.5, 3.0, 6.0, 12 and 20 m). At each sampling point, a square whose sides measured 1 m was sampled to collect the relative cover (expressed as %) of all the species present using an underwater camera or by scuba diving; at the same time, the main physicochemical parameters of the water column above the macrophyte stands and the sediments were analyzed. To test the non-random distribution of SAV, a null model analysis was performed using the Checkerboard-Score index. A Canonical Correspondence Analysis was performed to analyze the influence of environmental variables on species distribution and to explain the detected variability within and between lakes.

For the first time, using a co-occurrence analysis, we demonstrate the non-random structure of SAV in deep lakes according to a checkerboard scheme. The prevalent explanatory ecological factors of SAV distribution were water conductivity and Chl-*a* and sediment conditions. However, in two of the five cases analyzed, the SAV pattern was random, a condition that may be associated with a generally unstable or dynamic lake physicochemical status. A non-random model describes the depth distribution of SAV in deep lakes. However, the recording of significant C-scores was strictly dependent on the conservation status of lakes: low nutrient loads, in both water and sediments, appear to support non-random macrophyte zonation. Consequently, if we fail to assess SAV structure, we may not be able to identify the main ecological determinants of SAV distribution.

38-O   Effect of structure and magnitude in mechanical stressors induced by mean flow and turbulence on plants with different morphologies.   *Takashi Asaeda , Kelum Sanjaya*

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The Mean flow (MF) which is steady and unidirectional is the velocity averaged in a certain period. Turbulence (TB) is the deviation of instantaneous velocity from the mean. Some of the MF energy allocates to create TB, which always associates with high velocity flows, if the Reynolds number exceeds the critical value. The impact of these two components on aquatic plants is mechanically different. MF exerts unidirectional tension, while fluctuating forces and pressures in various magnitudes and directions are loaded by TB on plants. These two stressors occur together regulating the existence of plants in nature. However, proper evidences are lacking on their individual stress structures and strength.

The MF and TB experiments were conducted in closed microcosms. A gradually contracted transparent tube with plants at the middle, in a recirculating tank was used to obtain the MF of 14 cm s⁻¹ with negligible TB. Four intensities of TB; 0, 0.3, 0.6, 1.2, 3.0 cm s⁻¹ were generated by a vertically oscillating grid in tank with sand substrate. Three submerged plants; Elodea nuttallii, Potamogeton crispus and Vallisneria asiatica were grown in fixed nutrient condition with a controlled light regime for 8 weeks. Morphology, Cellulose, Lignin, H₂O₂, pigments, IAA, and antioxidant activities were measured in exposed plants. In addition, the tissues were observed by Transmission Electron Microscope (TEM).

Stem diameter and shoot elongation were lower in both MF and TB conditions. The strand length of V. asiatica was significantly higher in MF. Cellulose and Lignin content were increased with TB intensity and MF, while they were greater

in stems than leaves. The H_2O_2 content and antioxidant activities increased with TB and MF. But, those were opposite for V. asiatica in MF. In addition, H_2O_2 and antioxidant activities were higher in leaves than in stems. The plasmolysis and chloroplasts aggregation were observed in high TB, while no such anomalies were observed in MF.

The effect of MF depends on the plant morphology. Vallisneria sp. has leafy morphology, thus the laminar Boundary Layer (BL) which reduces with high velocity, forms on entire leaf surface by reducing the efflux of gases and elements and the matter efflux increases when the BL thickness reduces. The other two species with whorled morphology do not have such benefit. In addition, the high MF increases the tension stress to the plant body. The tension stress by MF on stems is higher than on leaves of whorled plants compared to TB. The rapid motion of TB creates a plasmolysis in cells and high diffusion rate of elements, thus, the negative effect is much stronger than MF. The cellulose and lignin contents were always higher in stems to strongly withstand against vigorous motion and tension in TB condition, thus the TB is more stressful than the MF on submerged aquatic plants regardless the plant morphology.

38-O   Impact of water level fluctuations on freshwater macrophytes.   *Elisabeth Bakker [1], Judith Sarneel [2]*

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Due to increasing variation in climatic conditions water levels of shallow water bodies are increasingly fluctuating. During periods of drought, this results in temporarily lower water levels as well as complete drawdown. These water regime changes are likely to strongly affect recruitment opportunities and subsequent plant community assembly in wetland ecosystems. In experiments, we found that water drawdown provided a clear window of opportunity for germination of macrophytes both from the seed bank and from dispersed seeds. Species traits, water levels and shore morphology together determine wetland plant community assembly, with dispersal as the main driver of seedling community diversity. In the field, the expansion of riparian vegetation depended strongly on water depth: the shallower the faster the vegetation expansion into open water, but only when protected from grazers, including waterbirds and muskrats, as these strongly inhibited vegetation expansion outside exclosures. For submerged macrophytes the effects of water level fluctuations are less straightforward, water level drawdown increases light availability, but in eutrophic systems also promotes the chance of cyanobacterial blooms. A complete drawdown may have the most positive results on the development of submerged vegetation after refilling of the water body. These results can be used to predict the impact of water drawdown as a result of droughts and to implement water management aimed at the stimulation of plant recruitment and diversity in wetlands.

38-O   Growth dynamics of two rooted aquatic plants of conservation concern: effects of sediment quality and grazing.   *Rossano Bolpagni, Federico Pino*

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The progressive reduction in underwater light availability and habitat fragmentation have been addressed as the main causes of decline in rooted aquatic plants throughout the world. However, open questions related to the causal factors involved in their local extinction and/or recolonization processes remain. Hence, a minor attention is generally attributed to the bio-receptivity of sediments. Despite this, the accumulation of nutrients and organic matter in surficial sediments increases their hostile behavior, enhancing the production of labile phytotoxic compounds and inducing stress on rooted macrophytes. Focusing on two rooted aquatic plants of conservation concern, *Hippuris vulgaris* L. and *Marsilea quadrifolia* L., we performed ex-situ growth experiments by microcosm incubations aimed to gain knowledge on their autoecology. In particular, this study focused on the characterization of changes in biomass and growth rates with increasing availability of nutrients (N and P) and reducing conditions in sediments. A second task was devoted to assess the impact of grazing on the growth responses of *H. vulgaris*, such as that potentially can be exerted by alien species like grass carp (*Ctenopharyngodon idella*) and coypu (*Myocastor coypus*). We confirm the pivotal role played by the sediment conditions in driving the growth performance of the two species, with higher rates in presence of the highest nutrient availability tenors. However, potential negative effects on plants vitality were noted in incubations with initial pore water concentrations of ammonia and reactive soluble phosphorous higher than 500 and 10 µM, respectively. Present results support the idea of the central role of sediment conditions in driving the bio-receptivity of an aquatic environment, suggesting further investigations on the day-night, and intra- and inter-seasonal variations of

redox-dependent processes in surficial sediments associated with human-induced organic matter and nutrient enrichment.

38-O   Effects of eutrophication and temperature rise on macrophyte stoichiometry and palatability to an omnivorous ectotherm.   *Peiyu Zhang, Reinier F. van den Berg, Elisabeth S. Bakker*

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Aquatic ecosystems have been subject to eutrophication and climate warming since the industrialization by strong anthropogenic activities. Both eutrophication and climate warming have potentially huge impacts on the trophic interactions in aquatic systems. We have explored the eutrophication and warming effects on food quality and palatability of macrophytes to their consumers. We chose the omnivorous ectotherm the Great pond snail (*Lymnaea stagnalis*) and its feeding on freshwater macrophytes as model system to investigate the effects of eutrophication and warming on their direct interactions. Macrophytes were cultured by adding nutrients (nitrogen (N) and phosphorous (P)) to simulate eutrophication and increasing temperatures to mimic climate warming in two separate experiments. Subsequently, the cultured plants were offered to the snails in 24-hour feeding trials. We found that aquatic plants have a flexible nutrient composition, which induced different palatability (indicated by plant consumption rate) to the omnivore. Both C:N and C:P ratios were negatively correlated with plant consumption rates. Eutrophication lowered the C : nutrient ratio in the plants, increasing the consumption rate. On the contrary, climate warming increases the C : nutrient ratio, which decreases plant palatability. However, despite the poorer quality of food in warmer conditions, herbivory is still stronger than in colder conditions, because the ectotherm animals need more food to satisfy their metabolism and the animals can potentially handle poorer food at higher temperatures. We conclude that both increasing eutrophication and temperature rise will result in enhanced plant consumption rates by ectotherm animals.

38-O   Calcification of *Nitella*: implication for phytoremediation of cesium contamination.   *Md Harun Or Rashid, Keerthi S. S. Atapaththu, Takashi Asaeda*

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Aquatic plants play a crucial role in aquatic ecosystem as they are involving in a wide spectrum of ecological functions. However, aquatic plants are persistently challenged by a vast array of abiotic factors such as water movements, substrate characters, nutrient availability, light penetration, UV radiation, temperature and heavy. Among them, toxic heavy metals have been identified as one of the main abiotic stress that adversely affect to the plant growth and physiology as a result of associated oxidative stress. Even though much attention paid on cesium (Cs) exposure on flora and fauna, oxidative stress in charophytes in response to former stress is largely unknown. Therefore the objective of present study was to evaluate the growth, stress response and the capacity of cesium uptake of carophyte; *Nitella* after being exposed to water born cesium. Stress response of *Nitella* were studied after being exposed to four concentration of Cs; i.e 0 (control), 0.001, 0.01 and 0.1 ppm. Our results suggested that Cs exposure reduced plant growth and affected plant functioning via activating the defense mechanism against oxidative stress in *Nitella*.

38-O   The aquatic macrophytes of Greek lowland river systems: assessing the ecological status in response to morphological degradation.   *Eva Papastergiadou[1], Giorgos Dimitrellos[1], Giorgos Kerametsidis[1], Katerina Kostara[1], Katerina Koutelida[1], Paraskevi Manolaki[2], Denis Tsoukalas[1]*

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Macrophytes are large freshwaters plants, which are easily seen with the naked eye. Because certain species and species groups are indicative for specific running water types and adversely affected by anthropogenic impacts, aquatic macrophytes can be considered as appropriate indicators of ecological quality in aquatic ecosystems. The importance of macrophytes in biological assessment is formally recognized in Europe under the Water Framework Directive 2000/60/EC (WFD) in which macrophytes are one of four key Biological Quality Elements (BQE's) for monitoring the

ecological status of surface waters. Under the WFD 2000/60 each Member State is required to devise a comprehensive national monitoring programme for surface waters, incorporating hydromorphological, physicochemical and biological elements. This paper describes a method of using the macrophytes for monitoring the ecological quality of Greek rivers. Furthermore, intends to investigate the relationship between ecological quality and habitat degradation and macrophyte assemblages.

The Greek national monitoring network for macrophytes consists of almost 100 lowland river sites belonged to RM-2 (Small/Medium lowland streams) and RM-3 (Large lowland rivers) Intercalibration Common (IC) types. The sampling sites are located at the greatest extent of Greece territory. Field monitoring campaigns conducted in spring–summer during the period of 2013-2015. Data from the rivers basin area were collected using the Mediterranean Geographical Intercalibration Group (MEDGIG) standardized protocol. Physicochemical, hydromorphological and macrophyte species data were collected and analyzed from all surveyed sites. Presence and abundance of macrophytes species were estimated in field according to MEDGIG suggested 5-point abundance scale.

The spatial pattern of the macrophyte assemblages within the monitoring network was analysed using Hierarchical cluster analysis (discrimination level > 70%) while detrended correspondence analysis (DCA) was performed to visualize the spatial relationships between species and plant assemblages. The differences between plant assemblages were estimated using per mutational multivariate analysis of variance (PERMANOVA) with Bonferroni correction and the taxa primarily responsible for the differences between plant assemblages were identified with Similarity Percentage analysis (SIMPER). Both geomorphological and physicochemical variables proved to be significant in the Monte Carlo permutation test. For determination of the effect of the environmental variables on macrophytes community types the redundant analysis (RDA) was used. The results indicated that 48 aquatic macrophyte taxa are present in the monitoring network forming four discrete clusters with statistically significant differences among them. Furthermore it seems that in typical Mediterranean middle-sized rivers of Greece, macrophyte assemblage structure was strongly associated with geomorphological features.

38-O   The macrophyte index for rivers (MIR) application to lowland rivers. *Krzysztof Szoszkiewicz, Szymon Jusik, Daniel Gebler*

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The variation of Macrophyte Index for Rivers (MIR) in rivers across a wide trophic gradient was investigated to evaluate their usefulness for river monitoring. The MIR index was developed for the purpose of Water Framework to evaluate the ecological status of rivers. It was implemented into national monitoring of Polish rivers in 2007.

Analyses were conducted at 100 sites. All of the survey sites represent a uniform abiotic type, i.e. small and medium-sized lowland rivers with a sandy substrate. Our database of physical and chemical parameters was shown to represent a very wide range of trophy, from reference sites to most degradated sites in Poland. The analysed database consisted of results of botanical surveys which were supplemented with comprehensive monthly physicochemical records. Based on the macrophyte data, MIR index was calculated as well as two other metrics indicating the ecological status of rivers as British RMNI and French RMNI. The studies showed that water trophy has a significant effect on the compositional variation of macrophytes in rivers. The variation of all the metrics used to assess the ecological status, between individual classes, identified based on physicochemical criteria, was close to linear and was statistically significant. Ecological status metrics showed a strong response to the water trophic level. We proved that vegetation diversification along a trophic gradient is evident enough to detect degradation in a five quality class system. Moreover, relationship between quality classes based on physico-chemical parameters and macrophyte-derived ecological classification was shown.

38-O   A national river vegetation classification system - the backbone to Irish river macrophyte monitoring and ecological assessment.   *Lynda Weekes [1] - Úna FitzPatrick [2] - Mary Kelly-Quinn [1]*

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A National River Vegetation Classification System (NRVC) for Ireland has been constructed using vegetation plots from a variety of sources including public bodies and academia. A classification system was recognized as an urgent need in Ireland as rivers are generally treated as one for management purposes and when reporting on a European level. They

are assigned to one main habitat type, the European Habitats Directive Annex I habitat code 3260 which covers a broad range of lotic vegetation communities from upland streams dominated by bryophytes and macroalgae to lowland depositing rivers characterised by the occurrence of pondweeds and starworts. This does not take in to account the wide variety of habitats that exist in Irish rivers, the NRVC provides a more detailed picture of aquatic river macrophyte community composition which will inform conservation evaluation, assessment and management.

The vegetation plots used to construct the classification are held within the River Macrophyte Database (RMD) which was collated for the purposes of this project and are stored within the database management system TURBOVEG held at the National Biodiversity Data Centre. The vegetation classification resulted in the identification of phytosociological macrophyte communities based on species composition (analysed initially by K means within the vegetation editing programme JUICE) and subsequently related to prevailing environmental conditions.

A NRVC of rivers in reference (minimal human interference) condition was also produced and will form the baseline for future assessment of conservation status and biodiversity monitoring. The urgent need to examine the composition and structure of macrophyte communities within these high status rivers is very important considering that rivers of highest water quality in Ireland has almost halved in the last two decades to just 17%. It is well known that macrophytes are useful indicators of water quality and at present, the Irish Environmental Protection Agency (EPA) are establishing the use of macrophytes to monitor the quality of the water by calculating the Mean trophic rank (MTR) for specific sites, however, this does not necessarily indicate overall ecological quality. This research examines plant communities as a whole in terms of their dominance, cover value and structure and seeks to address whether vegetation community composition differs significantly from communities found in impacted rivers and whether or not these macrophyte communities act as indicators of ecological quality as a whole in terms of biodiversity, not just water quality.

38-O   Macrophythes for the ecological assessment of watercourses in Italy: the use of IBMR_RQE and the new perspectives.   *Maria Rita Minciardi [1] - Concita Daniela Spada [1] - Laura Olivieri [1] - Silverio Abati [2] - Simone Ciadamidaro [1]*

Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), Laboratory of Biodiversity and Ecosystem Services. ENEA Research Center of Saluggia, Vercelli, Italy [1] - Department of Sciences, Roma Tre University, Rome, Italy [2]

The ongoing process of implementation of the Water Frame Directive 2000/60/EC in Europe led to the definition of an almost common methodology for the evaluation of the ecological status of rivers through macrophytes, which required the harmonization of new sampling approaches and standardization of the metric, and whose future developments are a nodal issue for plant bioindication studies.

The development of the method required the definition of a standardised sampling protocol, the identification of watercourse types, the formalization of the National methodology (IBMR_RQE, adapted from the *Indice Biologique Macrophytique en Rivière*) with National reference conditions and finally the intercalibration with other European methods. To set biological reference conditions (referable to the flora expected under undisturbed conditions) the metric value for communities in reference sites were predicted, rather than the taxonomic composition of the flora itself.

The vegetation species and the communities that may be found within rivers and stream, in undisturbed condition, are governed by a range of physical processes, which can be categorised into natural fluvial disturbance (water force), climate, soil moisture.

The continuous validation process carried out at National level is demonstrating good reliability of IBMR_RQE index in all the considered river typologies and for several human alterations, even if the index was primarily conceived to be sensitive to the alteration of the trophic status. However, when in presence of hydromorphological alterations impacting oligotrophic watercourses, the metric alone can result poorly sensitive to the effects on plant communities; nevertheless, such a gap is common to the other indices for WFD biological elements (macroinvertebratres, diatoms and fish). Notwithstanding this partial lack of IBMR_RQE sensitivity, macrophytes as a community surely respond to hydromorphological alterations, but the detection of the response depends on the choice of the evaluation metrics.

More in general, it is necessary to extract as much information as possible from the macrophyte community in order to evaluate multiple pressures and their effects under a multi-stressor environment, so to separate different alteration causes and to design appropriate measures. Therefore, the implementation process for a comprehensive and effective use of macrophytes in river bioindication should face the definition of new evaluation metrics and the design of sampling procedures at mesohabitat scale, differently adjusted on the basis of the river typology.

In conclusion, we suggest to not restrict the sampling exclusively to submersed mesohabitat, in order to put the stress on the linkage between macrophytes and the other plant communities along river corridor.

38-O   Modelling of macrophyte indices in hydromorphologically altered rivers.   *Daniel Gebler*

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The aim of the study was to determine relationships between macrophyte indices, physico-chemical parameters of water and the hydromorphological status of rivers. Studies were conducted on river sections strongly modified in terms of their hydromorphology. Additionally, the applicability of artificial neural networks (ANNs) in modelling of various macrophyte indices was analysed.
Three indices of ecological river status assessment were model using ANNs: the Polish Macrophyte Index for Rivers (MIR), the French Macrophyte Biological Index for Rivers (IBMR) and the British River Macrophyte Nutrient Index (RMNI) and additionally, two biodiversity indices (species richness and the Simpson index).
Water physic-chemical parameters, as alkalinity, conductivity, pH, biochemical oxygen demand, dissolved oxygen, total phosphorus, nitrate, nitrite, organic and ammonium nitrogen were utilized in each network as the explanatory variables. Moreover, two hydromorphological indices (Habitat Quality Assessment and Habitat Modification Score) were used.
The best modelling quality (the highest value of coefficient of determination and the lowest root mean square error) was obtained for RMNI and MIR network. The networks obtain for both biodiversity indices showed much lower quality. In all analysed cases, modelling quality improved as a result of adding HQA and HMS indices to the pool of explanatory variables. The significant effect of these two indices in the models is confirmed by the results of sensitivity analyses. This indicates the relationship of macrophyte metrics with the hydromorphological status of the surveyed river sites.

38-P   Comparison of the phytoplankton composition and abundance in charophyte- and angiosperm-dominated shallow clear-water lakes.   *Agnieszka Pasztaleniec, Agnieszka Kolada*

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In macrophyte-dominated shallow lakes, a clear-water state can be maintained by the dominance of either charophytes or angiosperms. The feedback mechanisms between phytoplankton and submerged macrophytes are hypothesised to be different in lakes with these two types of vegetation. We investigated the differences in the phytoplankton composition and abundance as well as the physicochemical properties of water between two groups of shallow clear-water lakes: dominated by charophytes (n=7) and angiosperms (n=6). Although the differences in the physicochemical parameters of water were statistically insignificant (ANOVA p>0.05), the phytoplankton abundance and composition, when analysed using the multivariate ordination techniques (DCA, CCA), clearly distinguished these two types of lakes. Phytoplankton taxa associated with macrophyte communities were identified. In both types of lakes the highest biomass was reached by bigger species from Dinophyceae and Chlorophyceae groups; however, in chara-dominated lakes, the taxa belonging to chrysophytes (the genera *Erkenia*, *Mallomonas* and *Dinobryon*), cryptophytes (the genus *Rhodomonas*) and chroococcales, a colony-forming order of cyanobacteria (*Aphanocapsa* spp., *Aphanothece* spp.), predominated, while in angiosperm-dominated lakes pennales diatoms (the genera *Fragilaria*, *Ulnaria*, *Asterionella* and *Tabellaria*) and filamentous cyanobacteria (*Aphanizomenon* spp. and *Anabaena* spp.) were most common. The differences in the taxonomic composition and structure of the phytoplankton may indicate that the ecological interactions between phytoplankton and macrophytes proceed differently and that other factors may be involved in maintaining the clear-water state in shallow lakes dominated by characeans and angiosperms.

38-P   Characterization of phenolic substances with allelopathic potential produced by emergent macrophyte *Phragmites australis* under a combined effect of light intensity and nutrients.   *David Chicalote-Castillo, Pedro Ramírez-García, Martha Lydia Macías-Rubalcava*

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It has been observed that in places where populations of *Phragmites australis* are present water quality and biodiversity is promoted, while it is also effective to reduce the growth of other species photoautotrophic. Based on the release of secondary metabolites such as phenols, it has been tested to have allelopathic potential to inhibiting the growth of cyanobacteria *Microcystis aeruginosa* (toxin producing), as well as other microalgal species that habit in eutrophic fresh water bodies. The ability to produce allelopathic substances as is the case of *P. australis*, is assumed as a characteristic mechanism for the success of invasive species. However, the variation in the production of allelopathic substances is associated with the limitation resources; therefore the deficiency in abiotic factors such as light intensity and nutrients can increase the allelopathic effect of *P. australis* on toxic phytoplankton species. The aim of this work was to test two light intensities, high (90 µmol photons m^{2}s^{-1}) and low (10 µmol photons m^{2}s^{-1}) and their combination with two concentrations of nitrogen and phosphorus, high (88 N**:** 5.5 P mgL^{-1}) and low (20 N: 1.25 P mgL^{-1}) on the production and release of phenols as: gallic acid, coumaric acid, ferulic acid, vanillic acid and (+)-catechin by emergent macrophyte *P. australis*. At the end period of 5 days treatment the exudates were analyzed by High Performance Liquid Chromatography. Same way the phenols contained in the root were analyzed in order to detect differences between the amount of phenols produced in it and released to the medium under both experimental conditions. We found that *P. australis* under deficient light intensity combined with the limitation of nitrogen and phosphorus, increases both the production and the release of phenols. Our results provide knowledge to understand how abiotic factors modify the allelopathic response of emergent macrophyte *P. australis*.

38-P   Morphological and anatomical diversity of reed stands developed in different water bodies of the Danube River.   *Attila Engloner, Ágnes Szakály*

Danube Research Institute of Centre for Ecological Research,, Hungarian Academy of Sciences, Budapest, Hungary$^)$

In order to reveal how the development of riverine reeds can be affected by different water regimes, we have studied the genetic and phenetic diversity of stands grown in 3 different habitats of the Danube river. In (i) an artificially controlled running water with low water level fluctuation, (ii) an oxbow with significant water level fluctuations related to the flood events in the main river and (iii) a separated oxbow which has lost connection to the main river channel.
This presenation describes the morphological and anatomical diversity of reeds, considering the following characters: the total stem length; the number, length and diameter of internodes; the number and length of leaf sheaths and blades; the radial thickness of the internode wall measured in transverse-sections and that of each tissue constituting it; and also the cross-sectional areas of aerenchyma channels and the innermost vascular bundles involving the bundle sheath sclerenchyma, phloem and metaxylem vessels.
Since the clonal diversity of the selected reed stands is already known, we are allowed to investigate the phenetic plasticity of identified clones so that the anatomical and morphological diversity affected only by habitat conditions can be revealed.
This work was supported by the Hungarian Scientific Research Grant (OTKA K106177) and the János Bolyai Research Scholarship of the Hungarian Academy of Sciences (BO 00513 13).

38-P   The role of macrophytes in the temporary mediterranean rivers of Cyprus: ecological status, habitat integrity, trophic level and species composition.   *Paraksevi Manolaki* [1] *- Eva Papastergiadou* [2] *- Dionisis Tsoukalas* [2]

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Aquatic macrophytes are one of the Biological Quality Elements (BQEs) in the European Water Framework Directive (WFD) 2000/60, for which status assessment must be defined in monitoring the ecological quality of inland waters. The WFD aimed an integrative assessment of water quality that is frequently being achieved through multimetric techniques.
This study suggests a normative methodology for the development and implementation of a Macrophyte Multimetric Index (MMI) using aquatic macrophytes, as a tool for the evaluation of the ecological status for intermittent Mediterranean rivers in Cyprus. Field survey data were collected from the rivers basin area using the MEDGIG standardized protocol. In each surveyed site physicochemical, geomorphological and macrophyte data, were collected

and analyzed. Presence of about 97 macrophyte species was estimated in field according to MEDGIG abundance scale. Floristic data form riverbed and margins were collected from sites with different degradation.

A system for the assessment of the ecological status of intermittent streams has been developed and the methodology has been applied and tested in a dataset derived from Cyprus. The goal of this multimetric approach is to incorporate in a single value different components of the biological community. The development of the MMI consists of the following steps: 1) selection of the most suitable form of a multimetric index; 2) metric selection, broken down into metric calculation, exclusion of numerically unsuitable metrics, definition of a stressor gradient, correlation of stressor gradients and metrics, selection of candidate metrics, selection of core metrics, distribution of metrics within the metric types, definition of upper and lower anchors and scaling; 3) setting class boundaries; 4) interpretation of results and assessment of all sampling sites.

Principal Component Analyses were conducted using the degradation variables that showed low redundant information. Macrophyte metrics were selected to show high response to degradation gradient. Correlation analysis between biological metrics and degradation variables revealed those metrics that are most responsive to river deterioration. The range of metrics under stressed and unstressed sites was set as a criterion of choosing the core metrics. Finally, four core metrics were selected to be included in the index. MMI was calculated as the arithmetic mean of the core metrics, the range of the index values under unstressed conditions was defined, and the five-class quality system was generated.

38-P Primary producers as bioindicators of nitrogen pollution in freshwater. *Davide Cicala, Edoardo Calizza, Giulio Careddu, Federico Fiorentino, Maria Letizia Costantini, Loreto Rossi*

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Urbanisation strongly impacts aquatic ecosystems by decreasing water quality and altering water cycles. Nutrient enrichment as a result of anthropogenic activity concentrated along the land-lake margin is increasing, and have multiple effects including changes in the biodiversity, productivity, species composition, and ecosystem functioning. To enable a sustainable management of waterbodies, the quantification of the temporal and spatial variability of pollution levels is essential and chemical analyses are often ineffective against low but continuous anthropogenic pressures. Stable isotopes have widely been used to identify sources of pollution in ecosystems. For example, increased nitrogen levels in waterbodies, caused by organic pollutants are accompanied by a higher nitrogen isotopic signature (δ^{15}N). On the other hand, nitrogen discharges of inorganic origin are reflected by lower δ^{15}N values. This phenomenon can be better detected in lower trophic levels and in particular analyzing the complex structure of biofilm composed by autotrophic microorganisms (algae and cyanobacteria), and heterotrophic organisms (microbes, fungi and bacteria) immersed in a polysaccharide matrix, called periphyton, that is strongly influenced from biological-chemical-physical changes in waterbodies. Also, it plays an important ecological role, being an habitat for many other species, as well as the first link between dissolved nutrients and subsequent trophic levels. The main aim of this study was to assess the suitability of the periphyton, as an indicator of environmental quality able to identify spatial and temporal variability of nutrient pollution in surface waters, through absorbing nutrients directly from the water column and showing varying isotopic signatures according to pollutants origin. The present study was carried on along the coastal waters of the volcanic lake of Bracciano (central Italy). The analysis of δ^{13}C and δ^{15}N showed a trend by which sites with high human activities (such agricultural and industrial point and diffuse drains,) had different δ^{15}N values; indicating groundwater and shallow inflows responsible of the differences between sites. We suggest that periphyton can become a robust tool for the detection and characterization of the dynamics of a number of emerging anthropogenic pollutants of concern in urban water systems, posing the isotopic analyses of authoctonous primary producers as a powerful tool to evaluate the ecological status of a waterbodies.

39. LARGE AND DEEP LAKES: ECOLOGICAL FUNCTIONS AND RESOURCE MANAGEMENT

39-O   Biomonitoring of Lake Onego and assessment of watershed role in the ecosystem functioning.

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Lake Onego is the second largest lake in Europe, with a surface area of 9 690 km^2 and a volume of 291 km^3. With the exception of several bays, the lake still preserves its natural state and high water quality. Lake Onego is invaluable ecological resource and the largest public drinking water supply. It requires organization of regular monitoring especially considering observed changes in anthropogenic load and climate changes. Due to Lake Onego morphometric heterogeneity and high variability of biota characteristics, studies of the lake ecosystem demands special methodological approaches. Slow warming during the spring period determines significant variations in phenology of plankton in different parts of the lake. Anomalies in the chemical composition of sediments associated with zones of tectonic faults predetermine a non-uniform benthos distribution. Anthropogenic factors increase the heterogeneity of Lake Onego ecosystem. Most deep water parts of the lake are oligotrophic. The main sources of pollution (pulp and paper sewage waters and municipal wastes) are located along the north-western bays. Observed structural changes of aquatic communities reflect the eutrophication of the bays. To assess the spatial and temporal variability of the biota, original methods have been proposed. The timing and duration of plankton phenological phases and their interannual variability were determined using the 40-year series of observations. To assess the sustainability of the lake ecosystem, the regression models were created on the base of Orthogonal Distance Regression method. To assess the distribution of benthos, the benthic biotic indices were proposed. Three zones which reflect specific features of benthic communities were identified: i) areas with anthropogenic influence; ii) areas with groundwater discharges; iii) deep parts of the lake with geochemical anomalies. The proposed methods can be used in the biomonitoring of large lakes of the boreal zone. The flows of organic carbon in plankton net were modeled. Revealed high degree of heterotrophy of Lake Onego defines a significant excess of carbon dioxide emissions over its consumption within intra-lake processes of organic matter mineralization. The reason of heterotrophic metabolism of the lake is a large number of allochthonous organic matter that enter from swampy areas. To evaluate the watershed changes during the last 20 years and to assess their influence on the Lake Onego ecosystem, remote sensing data were used. The study has been financially supported by the Russian Science Foundation (#14-17-00766).

39-O   Using 3D modelling for understanding spatio-temporal heterogeneities of phytoplankton abundance in Lake Geneva (France/ Switzerland).

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The quality of ecosystem services provided by lakes is related to the ecosystem structure and functioning. Protecting water bodies is becoming a global goal that requires monitoring for water quality assessment. In 2000, the European Parliament set out the European Water Framework Directive (WFD), a framework for managing and protecting water

bodies in Europe. Classification of water bodies into ecological quality status has been a key issue for implementation of that framework. In France, the assessment of the ecological quality of lakes is based on four measurements per year, vertically integrated over the euphotic zone at the deepest point of the lake. However, in large lakes, ecological parameters used for water quality assessment (e.g. chlorophyll-a concentration and Secchi depth) exhibit strong spatial heterogeneities. Consequently, the representativeness of those data might be questionable and needs to be verified. Moreover, understanding their spatial distribution and temporal dynamics, and to what extent they alter the water quality assessment, is essential prerequisites for objectively evaluating, protecting and restoring freshwater ecosystems. We analysed spatial variability of phytoplankton abundance in Lake Geneva (France/Switzerland) using the MEdium Resolution Imaging Spectrometer (MERIS) sensor and used outputs of a coupled three-dimensional (3D) hydrodynamic model Delft3D-FLOW to an ecological model (Delft3D-WAQ) in order to explain mechanisms responsible for the occurrence of hot-spot of phytoplankton abundance. While remote sensing provides horizontal instantaneous observation of integrated parameters, 3D modelling provides supplementary information on the vertical distribution and temporal variability. Results indicate temporal changes in the intensity of Chlorophyll-a horizontal heterogeneity. In spring, chlorophyll-a horizontal heterogeneity occurs because of an earlier onset of phytoplankton growth in some littoral area. Spatial differences in the timing of phytoplankton growth can be explained by spatial variability in thermal stratification dynamics and nutrient inputs from river. In summer, spatial heterogeneity presents transient dynamics and is characterized by local higher phytoplankton abundances in relation to the impact of basin-scale upwellings. Using the 3D model, we highlighted the influence of hydrodynamics on the phenology and abundance of phytoplankton and aim at providing information that could be used to improve sampling strategies for the water quality monitoring of large lakes such as Lake Geneva.

39-O   Responses of phytoplankton size structure to oligotrophication and climate variability.

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The size of phytoplankton species is considered a key trait as many physiological rates such as maximal nutrient uptake and light absorbance, as well as sedimentation rates and edibility are affected by the size of phytoplankton cells. Hence, phytoplankton size is expected to change as a consequence of environmental changes such as eutrophication, oligotrophication and/or climate change. Here we analyse the response of phytoplankton size to environmental changes in deep and large Lake Constance. As many other lakes Lake Constance went through a history of strong eutrophication and subsequent oligotrophication during the last century with increases and subsequent decreases of total phosphorus (TP) exceeding one order of magnitude. On average warming has increased epilimnetic temperatures by approximately 0.7 °C and has reduced the frequency of winter mixing. The response of phytoplankton to these changes has been investigated utilizing data from a fortnightly sampling programme covering the time period from 1965 to 2007. Analyses of these long-term data showed that annual average biomass of phytoplankton was rather stable at both, TP concentration above 35 μg/L (range: 35 – 87 μg/L) and below 35 μg/L (range 7 – 30 μg/L). At a threshold TP concentration of approximately 30-35 μg/L biomass dropped within a few years by 50 % suggesting a regime shift of phytoplankton biomass. The size structure of phytoplankton, e.g. mean, variance and the slope of the abundance-size distributions showed large seasonal and interannual variability. With oligotrophication mean phytoplankton size as well as the slope if the abundance-size relationship increased. The strongest change roughly coincided with the timing of the biomass regime shift.

39-O   Lake Garda as a paradigmatic case study of ongoing ecological changes in the large lakes south of the Alps.

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The largest (62-368 km^2) and deepest (251-410 m) lakes south of the Alps (Garda, Maggiore, Como and Iseo) are one of the most important lake districts in Europe. In the last decades, these lakes underwent important changes, which include the warming of the water column; the tendency to oligotrophication or stabilization of the concentrations of total

phosphorus (TP); the introduction of new cyanobacteria, i.e. the establishment of the water-bloom forming *Dolichospermum lemmermannii* since the 1990s, and the very last discovery of *Tychonema bourrellyi*, a species producing anatoxin-a (ATX, a neurotoxin). These changes will be critically described considering in detail the results obtained in the Long-Term Ecological Research station of Lake Garda.

From 1991 to 2015, the long-term increase of the mean annual water temperatures in the mixolimnion (0-50 m) showed a positive and significant trend (>0.025 °C yr^{-1}). The warming was confirmed also considering the satellite measurements of temperature of the surface waters since the 1980s. The deep hypolimnion (< 200 m) showed periods of warming caused by a downward transport of heat by turbulent diffusion during stratification, interrupted by irregular cooling and overturn during harsh winters. Overall, the frequency of mixing episodes decreased. The last circulation was observed in 2006; since then, the waters below 200 m showed a continuous warming reaching, in 2015, unprecedent temperature values, between 8.5 and 8.7 °C. These changes were paralleled by a continuous increase of TP in the whole water column until 2002 (ca. > 20 µg P/L), followed by a decrease (17-18 µg P/L). These changes concurred to affect the ecological features of the lake.

The first surface blooms of *D. lemmermannii* in Lake Garda were recorded in the 1990s. The introduction (in the 1960s) and expansion of this species was linked to the incipient eutrophication and to the lake warming, which is a general positive factor for the development of gas-vacuolated cyanobacteria. Nevertheless, while the impact of *Dolichospermum* was limited to the development of summer surface "oligotrophic" blooms, recent investigations showed that *Tychonema* was able to develop with biomasses as high as those of *P. rubescens*. These findings induce to change an important paradigm in the phytoplankton ecology of the southern perialpine lakes. In fact, until now, *Planktothrix* was the dominant cyanobacterium, and the only producer of microcystins (MCs, hepatotoxins). Conversely, many strains of *Tychonema* isolated in Lake Garda and in the other large perialpine lakes tested positive for the presence of the genes encoding ATX, and for the production of ATX. Since 2009, the increasing role of *Tychonema* was confirmed by the increase of ATX and the decrease of MCs. The causes will be discussed considering in particular the interactions between changes in the trophic level and lake warming.

39-O   A multi-proxy sediment study to assess long-term effects of nutrients and climate variability on the ecological dynamics of the largest Italian lake (Lake Garda).   *Manuela Milan* [1] *- Christian Bigler* [1] *- Richard Bindler* [1] *- Nico Salmaso* [2] *- Krystyna Szeroczyńska* [3] *- Monica Tolotti* [2]

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The study of lake sediments allows to place limnological investigations within a secular temporal perspective, providing a longer time-span compared to monitoring data. A multi-site and multi-proxy paleoecological approach was applied to Lake Garda, the largest Italian lake, in order to disentangle the effects of local anthropogenic forcings, such as nutrients, and climate variability on the lake ecosystem during the last few centuries.Short sediment cores were collected from the deepest point of the two lake basins: Brenzone (350 m depth) and Bardolino (81 m depth). Biological indicators(diatoms and Cladocera) were used to reconstruct changes in the aquatic food web and to define the lake reference conditions, while sediment geochemistry, analyzed by wavelength-dispersive X-ray fluorescence spectroscopy (WD-XRF), was investigated to obtain information on different physical or chemical processes affecting the lake and its catchment.

The selected biological proxies suggested stable oligotrophic conditions of Lake Garda until the 1960s, while the following lake nutrient enrichmentled to a drastic change in the phytoplankton community. The major climatic anomalies,i.e. the Medieval Climatic Anomaly and the Little Ice Age, did not apparently affect planktonic diatom taxonomic composition, while Cladocera showed changes in total abundance and speciescompositions. On the other hand, diatoms showed an indirect response to climate variabilitysince the beginning of the nutrient enrichment phase in the 1960s, while Cladocera revealed a weaker climate-response during this nutrient-driven period. This different response to nutrients and climate was put in relation with the thermal dynamics of large and deep lakes. In fact, climate variability regulates magnitude and frequency of thermal circulationin large and deep lakes, which in its turn controlthe degree of nutrient fertilization of the entire water column and the related phytoplankton growth.

Geochemical data showed a pronounced change in elemental composition since the middle of the 20th century, when major elements and lithogenic tracers started to decrease, while elements related to redox conditions and contamination (trace elements) increased. The general trends agreed with the biological records. However, some differences recorded in the two different basins of Lake Garda reflected the effects of local hydrological and sedimentation patterns.

This study outlined that the ecological conditions of large and deep lakes in Northern Italy, such as Lake Garda, are mainly driven by nutrient enrichment, and that climate change can effectively modulate the lake ecological response to nutrients. The results stresses that the establishment of sustainable management policies and realistic restoration goalsof large subalpine lakes, which are usually based on the definition of lake reference conditions, need to pay particular attention to lake-specific sensitivity.

39-O   Degenerative processes in a deep meromictic lake: anoxia, reducing conditions and internal loadings.

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Ecological studies in Lake Idro (Northern Italy), performed in the last five years (May 2010 - April 2012 and September 2013 - November 2014), evidenced a progressive deterioration of water quality and ecosystem status. The water column is permanently stratified and the chemocline is presently at about 40-50 m depth, out of a maximum depth of 120 m. The monimolimnion, which is ~50% of the water volume, is devoid of oxygen, with a concurrent accumulation of Fe^{2+} and Mn^{2+}, methane, dissolved sulphides, ammonium (NH_4^+), soluble reactive phosphorus (SRP) and dissolved reactive silica. Conversely, in the mixolimnion NH_4^+, SRP and trace metals are almost completely depleted, whilst nitrate is the main nitrogen species. The development of phytoplankton and the contribution of cyanobacteria to total biovolume are quite limited (<~10%), because of the moderate availability of nutrients in the upper layers. For the trophogenic waters, we can propose the term "meromictic induced mesotrophy". The littoral zone (<10 m depth) is colonized by a wide macrophyte belt, with the dominance of invasive elodeids. The internal SRP regeneration is recognized as a major P source, whilst nitrogen is mainly imported from the watershed. The meromixis is a critical threat to lake recovery. The reducing compound bulk in the monimolimnion can potentially account for an oxygen demand which is nearly threefold the actual oxygen availability. Hence, in case of complete water overturn, oxygen dilution and consumption, might lead to a critical oxygen shortage with a possible collapse of the aquatic food web, coupled with and exceptional fertilization of the surface waters. In fact, the monimolimnion and the surface sediment horizon have accumulated a great quantity of phosphorus. Here, the strong reducing conditions of the monimolimnion favour the SRP release from sediments: At the same time a very small quota of inorganic nitrogen is recycled into the water column. The resulting inorganic N to P ratio is thus imbalanced and can be recognized as a possible trigger of the development of toxigenic cyanobacteria. The internal P recycling, which greatly exceeds the external P inputs, can counteract the effort aimed at reducing the external loading. However, the P speciation indicates that, a significant quota of the sedimentary P is not readily available, constituting the so called calcium bound fractions, either authigenic or detrital. The P speciation and its potential availability have also been analysed in sediments at different depth, with different oxygen concentrations, in order to explore the effects of oxic to anoxic conditions on sedimentary SRP retention and exchanges.

39-O   Long-tern nutrient dynamics in a deep subalpine lake (Lake Maggiore, Italy): the role of atmospheric deposition, catchment sources and climate.

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Lake Maggiore, one of the deep subalpine lake (DSL) in Italy, achieved a stable oligotrophic status after a recovery process started at the beginning of the 1980s. As an effect of decreasing nutrient loads from the catchment, concentrations of total phosphorus (TP) in the lake reached values of 9-10 µg L^{-1} at winter overturn in the late 1990s. The oligotrophic condition was also testified by chlorophyll concentration of about 3 µg L^{-1} as annual mean.
TP concentrations constantly decreased within 1980-1995, whereas total nitrogen (TN) progressively increased in the same period and beyond, mostly due to nitrate (NO_3) concentrations. Despite the adoption of measures to control N input from the catchment, NO_3 increased in the lake, as an effect of the high atmospheric input of N affecting this area. Recently, a slight decrease of NO_3 and TN concentrations has been observed, mainly affecting summer values in the

upper water layer. A decrease in the atmospheric load of N was also detected in the last few years through the data collected at a number of monitoring sites in the watershed of Lake Maggiore.

The change point in NO_3 trend in the lake was around 2010; in the same period, both reactive and total phosphorus started to increase slightly, with TP moving from 9 µg L^{-1} as yearly average on the whole water column to 11-12 µg L^{-1}. Some re-arrangement inside the phytoplankton assemblage was also detected, such as the non-occasional record of "eutrophic" species among the dominant taxa.

The present work will present and discuss some hypotheses to explain these trends in nutrient concentrations, taking into account the role played by atmospheric deposition and meteorological drivers, such as precipitation regime. The catchment loads, calculated trough the chemical monitoring of the main tributaries, will be considered. The thermal regime of the lake, and particularly the mixing depth and its effect on nutrient replenishment at winter overturn, will also be discussed.

39-O   Biogeography of *Dolichospermum lemmermannii* (Nostocales, cyanobacteria) in european waterbodies: a multidisciplinary approach.   *Camilla Capelli* [1] *- Andreas Ballot* [2] *- Leonardo Cerasino* [3] *- Nico Salmaso* [1]

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The presence of *Dolichospermum lemmermannii* was documented in northern temperate and boreal regions, between the 40th parallel and the Arctic Circle. In the last decade, this species spread towards southern Europe, making its appearance also in the largest lakes south of the Alps (Garda, Iseo, Como and Maggiore). Extended surface water blooms of this species were observed in Lake Garda at the beginning of the 1990s, and afterwards in lakes Iseo (second half of the 1990s), Maggiore (2005), and Como (2006). Blooms were always observed in summer and early autumn, during calm weather.

The study of sub-fossil akinetes preserved in core sediments allowed antedating the introduction of this species in Lake Garda in the middle of the 1960s. The significant increase in water temperatures and nutrient enrichment of the lake seemingly supported the development of this species in the successive decades. Global warming is indeed considered one of the major factors favouring the invasion of Nostocales, particularly due to the ability of the large gas-vacuolated species belonging to this group to control vertical movements in stratified water columns.

The large perialpine lakes are a renewed tourist destination and an important source of water for drinking, irrigation and industry. The appearance of *Dolichospermum* in this group of lakes represents a new potential risk because of the previous identification of several toxigenic populations associated with animal poisoning events in northern European countries. Despite serious concerns raised by the ecological, health and economic impacts, a comprehensive taxonomical, ecological, and toxicological study was begun only very recently.

The variability of morphological features in natural populations of *D. lemmermannii* are quite wide and some strains showed high temperature optima. The recent expansion towards the south highlights the ecological heterogeneity of this species and the conceivable existence of different ecotypes. In this work, we report the results of a wide research aimed to deepen the biogeography of *D. lemmermanni* at a continental level, along climatic and trophic gradients. The research was based on a wide multidisciplinary approach, including taxonomical, genetic and metabolomic determinations of several strains. A phylogenetic analysis of the 16S rRNA and *rpoB* genes was followed by the identification of toxic strains, evaluating the presence of cyanotoxins (i.e. microcystins, nodularins, anatoxins, cylindrospermopsins, saxitoxins) by LC-MS and cyanotoxins encoding genes (*mcyE, anaF*) by PCR.

This study will allow understanding the ecological factors involved in the development of this recently expanding species, contributing to identify the better management options finalized to relieve the economic impact on the large subalpine lakes, which are increasingly more exposed to high anthropogenic activities and climate change.

39-O   Effects of eutrophication management on the interactions between zoo- and phytoplankton in a deep perialpine lake (Lake Lugano, Switzerland and Italy).   *Fabio Lepori, Andreas Bruder, Gabriele Consoli*

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We used three decades (1983-2015) of monitoring data from Lake Lugano (Switzerland and Italy) to assess the effects of eutrophication management on phytoplankton biomass and the interactions between phytoplankton and zooplanktonic grazers. We hypothesized that the eutrophication management would lead to: [1] a reduction in phytoplankton biomass, and [2] an increase in the relative importance of grazer control (i.e., top-down control) on phytoplankton biomass. Top-down control was expected to increase from hypertrophic to moderately eutrophic conditions because of increased palatability of phytoplankton and reduced fish predation. As expected, during the study period summer phytoplankton biomass decreased significantly in the lake, paralleling declines in P concentrations and trophic level (from hypertrophic to mesotrophic). Most of the decrease in phytoplankton biomass occurred during the first decade of the study, when P concentrations also showed the largest decline. Grazer control on phytoplankton biomass did not increase monotonically as hypothesized but showed a unimodal pattern, peaking during the middle of the study period. This pattern paralleled changes in the density of two large-bodied grazers (*Eudiaptomus gracilis* and *Daphnia longispina-galeata*), which were responsible for most grazing activity. A potential explanation for the decline in grazer control toward the end of the study period (which is now being tested) is that external pressures, including increased N loading and surface-water warming, reduced the resource quality of phytoplankton. Our results suggest that rising environmental pressures unrelated to P enrichment (e.g., warming and N-loading) can alter the expected trajectories of lakes recovering from eutrophication and lead to unforeseen ecological states.

39-O   Nitrogen dynamics in a meromictic subalpine lake: from watershed to in lake processes.

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Inputs of anthropogenic reactive nitrogen (Nr) to watersheds in excess of their processing and storage capacity, results in Nr export causing a cascade of detrimental effects in receiving aquatic ecosystems. Mass balance studies have demonstrated that lakes and reservoirs are landscape components that both process and sequester Nr in the terrestrial to marine aquatic continuum. However, little is known about the relative importance of different Nr retention/elimination mechanisms or factors that regulate these mechanisms, particularly in deep meromictic lakes. Prolonged stratification, persistent anoxia and the establishment of reducing conditions may profoundly influence the fate of Nr loads in these lakes. In this study, we analysed the spatial and temporal variability of microbial N-transformations in a sub-alpine meromictic lake (Lake Idro, Italy), in order to elucidate the role of denitrification as a N-sink for net anthropogenic nitrogen inputs (NANI) to the watershed.
Lake Idro is a highly productive lake that undergoes stable, and persistent thermal and chemical stratification, resulting in the accumulation of reducing compounds and dissolved nutrients in the monimolimnion (~50% of lake volume). Denitrification dominated microbial N-transformations in the oxic to anoxic transition zones of the epilimnion. In contrast, the monimolimnion was a source of regenerated ammonium and had a low capacity to buffer the incoming nitrogen load. NANI was relatively low, and dominated by atmospheric deposition and feed and food N-imports. Overall, the watershed had a relatively low capacity to retain/eliminate Nr inputs and annual Nr export accounted for close to 50% of the NANI.

39-O   Spatial and temporal dynamics of antibiotic resistance genes in subalpine Lake Maggiore and in its catchment area.   *Gianluca Corno, Andrea Di Cesare, Ester Eckert, Mario Contesini, Roberto Bertoni, Cristiana Callieri*

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Spread and persistence of antibiotic resistances (either Antibiotic Resistant Bacteria, ARB, or Antibiotic Resistance Genes, ARGs) in aquatic environments exposed to human activities is a major threaten for health systems at the global scale.
The microbial communities of lakes and rivers subjected to anthropic impact become a long term reservoir of ARGs, as a consequence of a number of ecological stressors sometimes not even related to the direct presence of the antibiotic itself. ARGs, which are often located on multifunctional mobile genetic elements, can be selected and co-selected as

adaptation to pharmaceuticals, to heavy metals, or to other chemicals or ecological constrains. For this reasons, once an ARG spreads within a microbial community is not surprising that its presence becomes constitutive for a long time.
We are presenting the results from our long-term (2013-today) study of the resistome of Lake Maggiore, the sixth largest Western European lake, and the most important Italian reservoir of freshwater.
We could assess at least two ARGs (against sulphonamides and tetracyclines) as constitutive within the microbial community of the lake, and other three genes against beta-lactams, macrolides, and aminoglycosides as occasionally present, sometimes even in very high concentrations. We therefore also measured the concentrations of those ARGs in other, less impacted, high mountain lakes and springs in the Lake Maggiore catchment area, in the six main tributaries and in two wastewater treatment plants discharging their effluxes directly into the lake.
Our results, coupled with a number of concomitant measures of the main limnological and microbiological variables for each sampling date and station, allows a depiction of the routes of antibiotic determinants contamination in the catchment area of Lake Maggiore, distinguishing between inputs of agricultural or urban origin and the related temporal variations.
The catchment area of Lake Maggiore represents the first geographically defined territory where such integrated monitoring is being performed, providing fundamental insights for the management of antibiotic release in anthropized environments.

39-O   Incorporating greenhouse gas emissions into ecosystem models with application to Lake Iseo.

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Management-oriented ecosystem models were originally developed in the early 1970's to assess the impact of nutrient loadings on lake eutrophication. As a consequence, their characterization of water chemistry was rudimentary at best. In the mid-1980s, stimulated by concern with acid rain, two principle modeling advances provided the theoretical basis for upgrading the chemistry in lake ecosystem models. First, the methodology for coupling fast equilibrium reactions with slow nutrient/phytoplankton kinetics was developed. Second, the modeling of sediment-water fluxes of solutes and gases was rigorously established. Although most currently available, open-source lake water-quality frameworks still focus primarily on nutrients and phytoplankton dynamics, the theoretical advances now make it possible to incorporate equilibrium chemistry into these frameworks. One benefit is that such expanded frameworks can be used to examine interesting questions beyond the traditional nutrient overenrichment problem.
In the present talk we focus on one such question: the determination of changes in greenhouse gas emissions as a lake becomes eutrophic. We do this using LAKE2K, an open-source, seasonal, 1D coupled hydrodynamic-ecological-chemistry model. The hydrodynamic model simulates the lake as a one-dimensional system consisting of three vertical layers and computes the interlayer mixing based on wind speed and water density. As is commonplace, the ecological model includes the simulation of plant photosynthesis/respiration, organic carbon decomposition, nitrification, denitrification, sediment nutrient and oxygen fluxes. However, several novel features are incorporated including new chemical state variables and algorithms to simulate alkalinity, inorganic carbon (and hence pH and CO_2), methane, sulfate, hydrogen sulfide, and nitrous oxide. Post processing provides lake managers with results in a decision-support format. This includes typical time series of nutrients, phytoplankton and oxygen, but additionally with time series and annual totals of greenhouse gas fluxes across the air-water interface as well as key optical variables (Secchi depth, turbidity, light extinction). An application to the Italian pre-Alpine Lake Iseo illustrates how the model can provide information supportive of management and decision making for lake systems that are experiencing watershed and climate modifications.

39-O   Chemical profiling of the bioactive metabolites produced by invasive cyanobacteria in perialpine lakes.

Leonardo Cerasino, Camilla Capelli, Nico Salmaso

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Cyanobacteria are known to produce toxic metabolites, such as microcystins, nodularins, anatoxins, and saxitoxins. Cyanobacteria proliferation represents, therefore, a serious risk in natural and artificial water bodies. Besides the ones

mentioned above, cyanobacteria produce many other bioactive compounds, which are less investigated but are equally important because they can be also toxic. The full determination of the chemical profile can be therefore very useful for a correct determination of the toxic potential inside a cyanobacteria population. Moreover, the chemical profile can have very important applications from an ecological point of view, since secondary metabolites play an important role in determining the cyanobacteria success over other organisms. The chemical profile (and consequently the toxic potential) is specific for any single species, and, within one species, can be subject to changes in response to environmental (biotic and abiotic) factors. We have started a detailed investigation aimed at defining the chemical profiling inside the cyanobacteria populations typical of the perialpine lakes. These lakes are experiencing the colonization of new algal species (i.e. *Dolichospermum lemmermannii* and *Tychonema bourrellyi*) and therefore we focused our attention on these species. We used LC-MS techniques for the determination of a wide panel of secondary metabolites classified in two major classes: *i)* alkaloids (anatoxins, cylindrospermopsins, saxitoxins) and *ii)* peptides (microcystins, nodularins, anabaenopeptins, aeruginosins, micropeptins, microviridins). We analyzed cultures of selected species as well as field samples. Analysis carried out on cultures allowed to identify molecules produced in lower concentrations. We found considerable differences among species in terms of nature and amount of secondary metabolites. For example, *T. bourrellyi* resulted to produce two neurotoxic alkaloids (anatoxin-a and homoanatoxin-a), while *D. lemmermannii* and *Planktothrix rubescens* did not; *P. rubescens*, instead, resulted to produce five different epatotoxic peptides (microcystins). A number of peptides in the mass range between 400 and 1100 dalton were also identified. The investigation allowed us to determine that the investigated cyanobacteria produce and release in the water many different compounds belonging to different chemical classes (anatoxins, microcystins, cyanopeptolins, aeruginosins, anabaenopeptins) and that each species has a specific chemical finger print.

39-O   Phytoplankton community response to extreme meteorological events in a deep alpine lake.
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In the course of climate change, extreme meteorological events (EMEs) like heat waves or heavy rainfall are expected to increase in frequency in central Europe within the next decades. These events can significantly alter nutrient, light and temperature levels in lake ecosystems. Protist communities are known to react immediately to abiotic changes and hence community composition may shift due to EMEs. Here, we show the response of protist communities, especially phytoplankton, to a summer heat wave in 2015 and heavy rainfall events in 2015 and 2016. In each case we sampled 9 stations across a deep meso-oligotrophic Austrian lake, Lake Mondsee. Water samples were taken from several depths of the upper 20 m or from 0-20 m using an integrating water sampler and nutrients as well as temperature, conductivity and pH were analysed. Nutrient inflows of the three main tributaries of Lake Mondsee were also monitored. Phytoplankton identification and biomass calculations were estimated using three complementary methods: FlowCAM, flow cytometry and light microscopy (Utermöhl technique). During the heat wave, we found relatively low horizontal variation but significant changes in phytoplankton community composition at the central station of the lake with increasing water temperature. Changes were not restricted to the epilimnion; for instance we observed a vertical shift in the *Planktothrix* peak at 12-16 m depth according to PE-levels and microscopic counts. During the heavy rainfall events we found significant variations of plankton community compositions at sampling stations across the lake, indicating a high horizontal variation. Our results show, that EMEs significantly alter phytoplankton community composition. As these communities constitute a fundamental part of limnetic food webs, EMEs have the potential to change the trophic structure of lake ecosystems.

39-O   Long-term ecosystem responses to multiple stressors in a large lake: a functional principal
components analysis.   *Andrea Arfè [1] - Piero Quatto [2] - Antonella Zambon [1] - Giuseppe Morabito [3] - Marina Manca [3]*

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In this study we describe from a Functional Data Analysis perspective the long-term (1981-2008) dynamics of Lake Maggiore, the second largest Italian lake, located in the subalpine lake district. Several physical (i.e. water temperature,

total phosphorus concentration) and biological variables (i.e. phytoplankton and zooplankton population density, biomass and cell size) were analyzed. Data, available only for the 1981-1992 and 1995-2008 periods, were collected as part of the long-term monitoring program of Lake Maggiore, funded since the late 1970s by the International Commission for the Protection of Swiss-Italian Waters (CIPAIS). The data gap between 1992 and 1995 coincides with the end of oligotrophication phase and the transition of the system to a more stable oligotrophic condition. Hence the 1981-1992 and 1995-2008 periods were analysed separately, allowing to distinguish between the effect of trophic change and the response of the system to other constraints, such as those due to climate variability. Specifically, in each period, the variation in time of the considered variables was characterized by means of penalized B-spline expansions and Functional Principal Components Analysis (FPCA). Briefly, first the standardized time-series for the considered variables were smoothed by means of penalized B-splines. This technique allows to fit the data points by a smoothed piecewise-polynomial function in a way that minimizes the "wiggliness" of the resulting curve (thus avoiding overfitting). Second, FPCA was performed on the B-spline-smoothed time series to assess the dominant modes of variation of their temporal trajectories. For both periods, the first 4 FPCs explained about 60% of the overall variation of the smoothed standardized variables (55% for 1981-1992, 65% for 1995-2008). The ordination along the four FPC indicates that, during the first period the zooplankton-related variables were strongly associated to changes in phosphorus concentration, whereas phytoplankton-related variables only showed a weak association. In the second period phosphorus was still important, although there was an increasing role of temperature: zooplankton again showed a strong association, but that of phytoplankton became also evident. The effect of anomalous environmental changes, characterizing distinct years, was also pointed out by FDA.

39-O   Deep lakes in the 19th, 20th and 21st centuries: shifting perceptions on potential, threats and management at Lake Tahoe, USA.   *S. Geoffrey Schladow , Shohei Watanabe, Goloka Sahoo*

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Lake Tahoe, USA, has only been identified on maps for 170 years, yet in this short period it has undergone tremendous changes in how it has been perceived and managed. In the first few decades it was considered an ethereal water body, capturing the imaginations of both artists and the founders of the new field of limnology. The subsequent thirty years saw the clear cutting of its watershed and a precipitous decline in water quality, a period that was followed by an equally rapid, natural recovery of the lake's natural physical and ecological integrity. Since that time, however, the lake has seen a steady succession of environmental threats. These have included species extirpation due to overfishing, the introduction of new species in all trophic levels, the impacts of increased urbanization and associated eutrophication, and most recently the impacts of climate change. Each of these threats has been met with a range of responses that include diversion of sewage outside the watershed, stringent land development codes, mandatory boat inspections, and prescribed pollutant reduction targets. Many of these measures have been successful, in part because they were based on an understanding of the physical and ecological cycles at play within the lake. However, with climate change, these physical and ecological processes are showing signs of greater change than has previously been experienced, and shifts toward regimes that have never been experienced. These changes will be described using a combination of field measurements and numerical modeling results, and the range of potential management responses will be discussed.

39-O   Population structure of vendace in L. Vänern – what can be inferred from multiple sources of information?   *Alfred Sandström, Thomas Axenrot, Stefan Palm*

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Fish species in large lakes may occur in more or less discrete sympatric or allopatric populations. Typical drivers of the persistence of local subpopulations are local migration barriers, habitat patchiness and homing behavior. We aimed to investigate if potential local populations of vendace (*Coregonus albula*) in Lake Vänern, the largest lake in the EU, may be separated by a migration rate low enough to allow for independent demographic dynamics but large enough to prevent other than subtle genetic differentiation. Lake Vänern consists of two main basins, Värmlandssjön and Dalbosjön, separated by a shallow sill potentially reducing fish migration. Vendace are of high importance to the food

web as well as for the local commercial fishery, and the population structure of the species is important for its management.

We analyzed results from an annual monitoring program covering the whole pelagic part of the lake in late summer, a questionnaire to commercial fishermen, data from the fisheries and additional samples of vendace collected during spawning in late autumn. Our analyses covered a large number of parameters: genetic variation, demographical variation (spatial synchrony in population growth rates based on abundance, size and somatic growth), diet, stable isotope levels (d15N and d13C) and migration patterns.

Vendace were abundant in both basins and young-of-the-year and older vendace were found in both basins, although the relative abundance of life stages differed. Preliminary results from microsatellite analysis did not provide any clear support of genetic differentiation between basins. In contrast, demographic analyses indicated that the population growth rate patterns were not synchronous, implying independent dynamics in the two basins. We conclude that it may be important to combine genetic analyses with other sources of information, such as demography and migration rate, when providing advice for local management of important fish stocks.

39-P   Plasticity in phytoplankton annual periodicity: an adaptation to long-term environmental changes.   *Orlane Anneville [1] - Gaël Dur [2] - Frédéric Rimet [1] - Sami Souissi [2]*

INRA, UMR CARRTEL, Thonon Les Bains, France [1], Université De Lille, Umr 8187, Log, Wimereux, France [2]

Many phytoplankton communities present a strong seasonal pattern in terms of abundance and composition. This pattern is usually described as an annually repeated process of community assembly driven by changes in physical factors, grazing pressure and nutrient limitations. However, climatic changes, in combination with local phosphorus management policies have caused important modifications of the environmental conditions in many lakes during the past several decades. Lake Geneva is one of the systems affected by both climatic induced changes and a strong decrease in phosphorus concentrations. In this study we used monitoring data of Lake Geneva to test whether annual patterns of phytoplankton seasonal succession present inter-annual variability in relation to those environmental changes. Our approach combined i) the identification of species assemblages using a developed Bayesian method and ii) wavelet analysis to detect transient dynamics in seasonal periodicity. A decrease in phosphorus concentrations appeared to play a major role in the inter-annual replacement of species assemblages, but the results also exhibited transient dynamics that were most likely induced by changes in *Daphnia sp.* abundance. The observed transient dynamics in the abundance of species assemblages induced a strong inter-annual variability in the pattern of their seasonal successions, but they did not necessarily affect the annual dynamics of total phytoplankton abundance. Accordingly, we demonstrated that plasticity in the pattern of seasonal succession played a stabilizing role at the community level. The exception being at the end of the studied period, in the mid-00's when almost all of the assemblages lost their seasonality. The results suggest that seasonality and inter-annual changes in seasonal dynamics of species assemblages are important components to consider for underlining and explaining long-term variability in phytoplankton community.

39-P   Trophic role of crustacean zooplankton and transfer of POPs through the pelagic food web.
Roberta Piscia [1] - Roberta Bettinetti [2] - Emanuuela Boggio [2] - Rossana Caroni [1] - Marina Manca [1]

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Crustacean zooplankton is the major link between primary producers and zooplanktivorous fish in the pelagic community of lakes. They play a crucial role in the transfer of matter, energy and pollutants to higher trophic levels. The composition of the planktonic crustacean population largely varies with the season, Contribution of primary consumers to total net zooplankton biomass being prevalent in spring and early summer and that of secondary consumers prevalent in autumn and winter. Despite comprising two clearly different trophic levels, zooplanktons are often regarded as a one functional group, particularly in ecotoxicological studies and in models dealing with biomagnification and the role of zooplankton in transfer of pollutants to fish.

In the present contribution, we provide results of a pluriannual study on the deep subalpine Lake Maggiore (Italy), in which seasonal changes in carbon and nitrogen stable isotopes of zooplankton primary and secondary consumers were individually investigated. Results provide evidence that quantitative estimates of trophic roles within crustacean

zooplankton are essential for understanding fluctuations in POPs (persistent organic pollutants) concentration in different compartments of the pelagic food web.

39-P Limnology at work: when scientific research leads to the successful recovery of the polluted Lake Orta. *Monica Beltrami, Pietro Volta*

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Lake Orta (18.2 km^2, 1.3 km^3, 143 m max depth) has been severely polluted since 1926, when the lake began to receive industrial effluents containing high concentrations of copper and ammonia. Chromium-, nickel-, and zinc-rich effluents from plating factories have also contributed to pollution levels, and pH dropped below 4.0 as a result of the oxidation of ammonia to nitrates. More than 60 papers have documented the evolution of the chemical characteristics of both water and sediment, and the sudden decline of plankton, as well as benthos and fish. As a remedial action the lake was limed from May 1989 to June 1990 with 10,900 tons of CaCO$_3$. The treatment was immediately effective in raising the pH and decreasing the metal concentrations in the water column, and plankton and fish communities quickly rebounded, albeit as a poorly structured biological community. In the following years, the post-liming recovery of Lake Orta was tracked by monitoring its hydrochemistry and running a series of ecotoxicological studies. In 2015, a new research, based on toxicity testing of the main tributaries and the lake water column, coupled with the chemical assessment of the water quality, re-assessed the lake conditions and the real improvement of the environment.

39-P Water quality and long-term trends in the trophic conditions of the manmade Pertusillo lake (Basilicata, south of Italy): review of 50 years of monitoring activities. *Maria Francesca Scannone* [1] - *Vito Dario Colucci* [2]

University "La sapienza", Roma, Italy [1] - Fondazione Eni Enrico Mattei, Viggiano, Italy [2]

The aim of this study was to describe and discusses the long-term trophic conditions of the Pertusillo lake, a manmade lake completed in 1962. It is one of the strengths of Basilicata and Puglia regions water supply schemes, in fact, the water is employed into a hydroelectric power plant, for irrigation and production of drink water. The lake lies within a National Park and in the same area, are also located: the largest oil field of Continental Europe, 30.000 inhabitants, industrial, agricultural and zootechnical activities, authorized and illegal discharges of waste water. The study provides an overview of the complex dynamics of the lake Pertusillo, that is also subjected to a natural eutrophication process. The assessment of long-term ecological status was conducted through the collection and interpretation of historical dataset. The dataset was obtained from the review of 50 years of different monitoring activities (since 1963 to 2012), conducted by research centres, universities and regional environmental agency. The research has showed that the Pertusillo is a mesotrophic lake, and the water body has presented an accentuated trophic level just a few years after it was built. The lake has an extended summer stratification (thermal gradient of 12°C). The transparency, variable from 1 to 4 meters, is strongly influenced by the presence of suspended particles of silt. Oxygen concentrations vary from values of supersaturation (> 120% O$_2$) to anoxic values (<5% O$_2$). In this review, special attention is given to nutrients and phytoplankton dynamics, furthermore, a significant relationship between the level of nutrients and algal biomass has been established. The historical analysis of the algal species suggests that the present composition is not significantly different than in the past. It is therefore plausible to assume that the lake has not undergone radical environmental changes in 50 years. The seasonal increases in phytoplankton production (algal blooms) have favored anoxia condition in the hypolimnion during 1970, 1990 and 2010. Environmental data show that the lake had an experience of eutrophication in the 2010, while has recovered a mesotrophic status in 2012. Pertusillo lake has particular geomorphologic conditions which do not exclude a early silting of the lake basin and a subsequent self-cleaning capacity reduction of the lake. In conclusion, the knowledge of long-term trophic conditions can constitute a reference point for future actions to be taken to reduce the loads of nutrients incoming to the lake. Moreover, the monitoring of naturals and anthropogenics pressure represents a relevant environmental challenge.

39-P   Bentification in Naroch Lakes (Belarus). *B. Adamovich, T. Makarevich , Yu. Veras, H. Zhukava, T. Zhukava*

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Naroch Lakes are located in the northwest of Belarus in Neman river basin. The Lakes are connected through channels and include three water bodies: Lake Batorino, Lake Miastro and Lake Naroch. All the lakes are polymictic but differ in trophic state. As a result of about 60 years monitoring observations, a number of external factors that largely determine the stages of ecosystem evolution of Naroch Lakes and their current status have been identified.

In the end of the 20th century all the three lakes were affected by invasion and mass-scale reproduction of the Ponto-Caspian water-filtering mollusk, the zebra mussel (Dreissena polymorpha Pallas). The invasion by the zebra mussel causes complex and diverse rearrangements in the structure and functioning of lake ecosystems (Mayer et al., 2002; Mills et al., 2003).

Zebra mussel invasion led to the bentification process in the Naroch Lakes. Such parameters as nutrient concentration, phytoplankton biomass, chlorophyll and seston content and other indicators of bioactivity have decreased in water, but that was accompanied by appreciable increase in bioactivity of benthic communities (Ostapenya et al., 2012).

Our analysis showed that the responses of all the three lakes with common catchment area to the intensive nutrient load in the early 1980th and its subsequent decrease due to the implementation of the environmental improvement measures in the middle of 1980th were similar. But Dreissena invasion led to divergence in the dynamics of hydroecological parameters between lakes. The main factors that determine the development of zebra mussel population are the amount of available substrate for colonization, the morphometry, and the trophic status of lakes (Burlakova et al., 2006). The differences in the timing of zebra mussel invasion and certain differences in biotic and abiotic features of the lakes could determine the differential impact of the life activities of zebra mussel on each of the Naroch lakes.

39-P   Hydrological dynamics affect the development of phytoplankton in a large subtropical reservoir (Hongfeng, Southwestern China). *Qiuhua Li [1,3],Teng ou [1], Jing Xiao [1], Jingfu Wang [2], Jingan Chen [2], Nico Salmaso [3]*

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In the tropical and subtropical reservoirs, the control of primary production is generally exerted by bottom-up processes, especially represented by the control by P and N compounds, and by the hydrological dynamics. Moreover, compared with natural lakes in the temperate regions, top-down control of phytoplankton in tropical regions tends to be less important due to a general smaller size of zooplankton and to the high predation exerted by continuously reproducing omnivorous fish. Given these conditions, situations characterized by periods of low water renewal coupled with high availability of nutrients, can represent a serious hazard, favouring the potential development of nuisance species belonging to cyanobacteria, and compromising the exploitation of the reservoirs.

In this contribution, we will evaluate the influence of the hydrological regime and nutrient temporal dynamics on the development of phytoplankton and cyanobacteria in the sub-tropical Hongfeng reservoir (Southwestern China, Guizhou Province, 26.5°N). The reservoir has a surface area of 57.2 km^2 and a volume of 6.01×10^8 m^3. Since 2000, its major function changed from electricity generation to drinking water supply. From January to May, the water level of the reservoir was stable, oscillating between 1232 and 1234 m a.s.l. (low level). During June, the lake increased its level around 1238-1239 a.s.l. between July and December (high level). The high influx of water, which contributed to prevent the formation of strong temperature gradients, was followed by a decrease in TP concentrations from the low level (ca. 35 µg P/L) to the high level (25 µg P/L) period. At the same time, the phytoplankton community showed a decrease of biovolumes and a shift from cyanobacteria (mostly Oscillatoriales) and large diatoms to specific Morpho-Functional Groups belonging to small chlorophytes (small Naked and Gelatinous chlorophytes) and Small Centric diatoms. Overall, the increasing water influx favoured a decrease of the large species, in favour of smaller species. Changes at the species and at higher taxonomical levels were investigated by applying NMDS ordination techniques coupled with vector fitting. In particular, the phytoplankton sample configurations were significantly linked to the fluctuations of the water level and mean water temperature and, partly, TP.

Overall, the results demonstrated a clear negative link between phytoplankton development and increase in the water level. High influx of water and turbulence levels after spring contributed to control, despite medium-high concentrations of TP, the development of high phytoplankton and cyanobacterial biomasses. This works clearly demonstrates the strong implications originating from the adoption of different water discharge management options on the control of phytoplankton dynamics and potential nuisance species.

40. RESTORATION OF LAKES AND RESERVOIRS THROUGH GEO-ENGINEERING TECHNIQUES: POTENTIALS AND LIMITATIONS

40-O   Internal load in lakes: some considerations on importance and uncertainties. *Gianni Tartari, Franco Salerno, Gaetano Viviano, Lucia Valsecchi, Diego Copetti*

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The nutrient internal load is a component of the mass balance of a lake that can play an important role in the lake metabolism. Its source is generally associated with two main phenomena: the resuspension of the sediments, in the case of shallow lakes, and the release of nutrients (phosphorus and nitrogen) and other dissolved substances (i.e. iron, manganese etc.) both in deep and shallow lakes during the anoxic conditions.

In the case of total phosphorus, the external load by the tributary network can be determined very accurately using continuous measurement systems (on an hourly basis) of a proxy such as turbidity. In the same way, it is possible to calculate the loads of CSOs (combined sewer overflows) discharging directly into the lake body. Good approximations are also available for the riparian loads and impermeable surfaces loads using GIS (geographic information systems) techniques, land cover data and appropriate removal coefficients. Other sources of phosphorus, generally less relevant, are the dry and wet atmospheric depositions, the resident and migratory birds etc.

The internal load may compete in importance with the external load, in the case of shallow lakes, but plays also a significant role in the recovery of the trophic state in medium-depth lakes (i.e. 10-50 m). For this reason, the accurate determination of internal load is requested, but many difficulties in the assessment exist and this can directly influence the efficiency of the intervention and the management of the water quality. Approaches to internal load quantification are in general: the in situ determination from hypolimnetic total phosphorus increases, the mass balance approaches measuring input, output and sedimentation, the estimates from anoxic active area and sediment phosphorus release (Nürnberg 2009).

The management of the internal load of phosphorus can be done indirectly through the reduction of external loads up to the critical values for the water quality objectives (i.e. oligotrophic or mesotrophic state), or directly through the application of flocculation agents and other products as "capping" materials. Indirect interventions generally require long times (even decades), associated with the control of point sources, but usually give results stable over time. The approaches of geo-engineering instead give immediate responses in the short term, but little known are the durations of the effects. In addition, the direct interventions cannot be carried out if important interventions on the sources of phosphorus in the basin are not made.

In this paper are shown some thoughts about measuring internal loads, as a support tool for geo-engineering interventions, and presented a case study in which the internal load was reduced by the combined action of the management of external loads and manipulation the water budget.

40-O   A review on the use of lanthanum modified bentonite to manage eutrophication in surface waters.   *Diego Copetti [1] - Karin Finsterle [2] - Laura Marziali [1] - Fabrizio Stefani [1] - Gianni Tartari [1] - Grant Douglas [3] - Kasper Reitzel [4] - Bryan M. Spears [5] - Ian J. Winfield [6] - Giuseppe Crosa [7] - Patrick D'Haese [8] - Said Yasseri [2] - Miquel Lürling [9]*

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In this contribution we review the available knowledge on the use of lanthanum modified bentonite (LMB) to manage eutrophication in surface freshwaters. LMB acts binding orthophosphate ions (PO_4) both in the water column and in the sediments thus reducing the phosphorus bioavailable for primary production. This product has been applied in around

200 environments worldwide and it has undergone extensive testing at laboratory, mesocosm and whole lake scales. The review is based on more than 40 peer reviewed papers available on this topic, but it also takes into account some relevant data contained only in technical reports.

The results of the review exercise can be summarized as follow:

- the majority of the data related to the efficiency of LMB indicated effective reduction of soluble reactive phosphorus (SRP) concentrations in the water column and control of sediment SRP release, under most environmental conditions and across laboratory, mesocosm and field scale trials in freshwater ecosystems;

- the operational performance of LMB is reduced in the presence of humic substances and in the presence of oxyanions competing with PO4;

- LMB application during algal blooms is not recommended, due to the generally observed high pH and low SRP concentrations;

- the use of LMB in low alkalinity waters needs thorough pretreatment testing to ensure that free lanthanum is not present in the water, as a consequence of the LMB application;

- lanthanum concentrations detected during or immediately after a LMB application are generally below acute toxicological threshold of different organisms, with the exception of zooplankton species (e.g. Daphnia magna and Ceriodaphnia dubia);

- to date there are no indications for long-term negative effects on LMB treated ecosystems, however, potential issues related to indirect effects at varying trophic and biological levels still need to be explored;

- the human health risks associated with LMB treated surface waters appear to be negligible.

40-O   The fate of lanthanum in the sediment, water column and biota after the application of the lanthanum modified bentonite (Phoslock®) to mitigate eutrophication in Lake Rauwbraken.   _Frank van Oosterhout, Miquel Lurling_

Department of Water Quality and Water Quality Control, Wageningen University, Wageningen, Netherlands

We field tested the lanthanum modified bentonite (LMB, Phoslock®) as phosphate (P) fixative to mitigate eutrophication in Lake Rauwbraken (2008, The Netherlands). Besides testing its efficacy in controlling eutrophication, we also censored for potential unintentional side effects. To reveal the fate of the LMB's active ingredient (La) we monitored the lake's several years after the treatment. The application achieved a homogeneous distribution of the LMB on top of the sediment, 3 years afterwards most of the LMB was located deeper in the sediment and deeper in the lake. While most of the La resides in the lake's sediment, our results show that both filterable and non-filterable La are present in the water column and that elevated La concentrations are found in macrophytes, chironomid larvae, crayfish - experimentally confirmed, and fish. The filterable La likely is comprised of colloids and given the environmental conditions in Lake Rauwbraken the La species can be viewed as non-reactive. Nonetheless, our results indicate that some of the introduced La may go around in the lake's food web. We advocate that all lake remediation activities are followed up by prolonged monitoring.

40-O   Assessing the need for geo-engineering at the national scale, UK.   _Bryan Spears_ [1] - _Philip Taylor_ [1] - _Stephen Maberly_ [2] - _Jo-Anne Pitt_ [3] - _Linda May_ [1]

Centre for Ecology & Hydrology, Edinburgh, United Kingdom [1] - _Centre For Ecology & Hydrology, Lancaster, United Kingdom_ [2] - _Enironment Agency, Great Yarmouth, United Kingdom_ [3]

In England and Wales, some two thirds of lakes greater than 1 ha in surface area are likely to require external P load reduction to meet EC Water Framework Directive (WFD; 2000/60/EC) targets and a similar situation exists across other EU member states. However, many of these lakes are shallow and likely to suffer from internal P loading problems once these external loads have been reduced. Management options to address these internal P loading issues include the use of geo-engineering products, an approach that is becoming increasingly popular and has been used with varying degrees of success.

With evidence growing to support the use of geo-engineering materials in lakes for eutrophicatoin management there is a need to assess the suitability of the approach at the large scale. Most studies assessing the efficacy of the approach have been conducted at the laboratory or single site scales, with the exception of a few multi-lake analyses of responses in treated lakes. These studies have provided important knowledge on factors that confound the operatonial performance of geo-engineering materials that, when combined with national scale water quality monitoring data, can

provide insights into the wider suitability of the approach to meet wide reaching water quality targets. It should be noted that national scale assessments are not proposed here as a substitute for site-specific assessment of candidate lakes preceding treatment.

Using monitoring data supplied by the UK Environment Agency, and collected to fulfill their requirements under the WFD, we assess the use of national scale (i.e. 437 lakes) monitoring data to identify the proprotion of lakes in which geo-engineering (with La-bentonite) would be a suitable management approach. We report on the construction and application of a data screening procedure which catagorises lakes based on catchment P load and evidence of internal P load as well as a range of potentially confounding factors including dissolved organic carbon concentrations, lake depth and fetch, nitrogen limitation of the phytoplankton and water residence time. We demonstrate that catchment P load reduction remains an important precursor to geo-engineering across many of our lakes and that few lakes represent ideal candidacy for geo-engineering, alone. We present these results in the context of cost estimates for treatment at the national scale to meet WFD total phosphorus targets.

40-O   Impact of Phoslock® addition on sediment-water-atmosphere greenhouse gas fluxes in a eutrophic lake.   _Alanna Moore, Fraser Leith, Bryan Spears_

Centre For Ecology And Hydrology, Bush Estate, Edinburgh, United Kingdom

Internal phosphorus (P) loading from lake bed sediments is a common problem in shallow lakes. It acts to prolong, sometimes for decades, ecological recovery from eutrophication following reductions in nutrient loading from the catchment to the lake. However, current water quality legislation, including the EU Water Framework Directive, provides guidance on deadlines by which ecological improvements must be made. There is, therefore, a perception that measures must be developed and implemented to 'speed up' the recovery of lakes following catchment management. Such measures can include physical sediment removal activities or the use of additives, such as Phoslock®, to 'cap' P in bed sediments. Recent studies have also highlighted the importance of lakes as reactors of terrestrially derived carbon (C) and nitrogen (N) acting as hotspots for greenhouse gas (GHG) emissions. Given that biogeochemical cycles of C, N and P may be linked, we hypothesised that rapid control of the P cycle using Phoslock would disrupt C, and N cycling across sediment-water-atmosphere interfaces and set out to test this hypothesis using a laboratory controlled intact sediment core experiment.

This study used replicated sediment cores from Loch Leven, an untreated shallow eutrophic lake in Scotland, to quantify the effects of Phoslock addition on the P, C and N fluxes across the sediment-water-atmosphere interfaces. Six cores were dosed with Phoslock (equivalent to 0.68 kg m^{-2}), while the remaining six were left as controls. Following treatment with Phoslock, changes in nutrient and GHG fluxes between sediment cores were analysed over a 10 day period. These results will be set within the framework of eutrophication management needs in the context of GHG emissions, and recommendations are made for future experiments to examine the linkages between eutrophication and GHG emission control in lakes.

40-O   Assessing macrophyte responses in Phoslock® treated lakes.   _Kate Waters [1] - Iain Gunn [2] - Nigel Willby [3] - Said Yasseri [4] - Stephanie Cole [5] - Andrea Kelly [6] - Miquel Lürling [7] - Genevieve Madgwick [8] - Sebastian Meis [9] - Frank van Oosterhout [7] - Jo-Anne Pitt [10] - Iaine Sime [11] - Bryan Spears [2]_

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Chemical recovery in lakes following successful catchment management is often constrained by the release of legacy phosphorus (P) from bed sediments to the overlying water column. This process known as internal loading, can delay recovery from eutrophication for years following successful catchment management. In addition, ecological recovery can lag behind chemical recovery due to feedback mechanisms that maintain the status quo within populations, even

when environmental conditions are favourable. The use of geo-engineering (or 'P capping') for reducing internal P loading offers the opportunity to study ecological recovery processes following rapid chemical recovery in lakes. We draw on data from multiple lake experiments in which Phoslock®, a lanthanum-bentonite modified clay was applied to control internal P loading resulting in increased water clarity and reduced water column P concentrations. We focus on examining the evidence for recovery in the macrophyte community following Phoslock® applications including, for example, assessing changes in macrophyte functional groups, macrophyte percentage cover and lake macrophyte nutrient index scores. Concluding remarks will focus on discussing the ecological processes that are holding back macrophyte recovery in these treated lakes.

40-O   Control of benthic blue green algal growth: a case study from an Austrian recreational lake.

Said Yasseri

Institut Dr. Nowak, -, Ottersberg, Germany

The Reither See is a popular recreational lake located in the Austrian municipality of 'Reith im Alpbachtal' in the state of Tyrol.
The natural lake, which has a surface area of 1.5 ha and a maximum depth of 7.7 m, became increasingly eutrophic during the sixties due to inflows containing minimally processed wastewater and run-off from the surrounding agricultural catchment. In order to reduce the trophic state of the lake, measures to improve the water quality of inflows and lower nutrient inputs were commenced in the early seventies. An "Olszewski tube" was installed and iron(III)chloride was applied to remove high phosphate concentrations in the hypolimnion. Although nutrient loads have been reduced over the past 40 years, water quality problems still persist due to the ability of benthic algae to derive phosphorus from sediments. The emergence of massive mats of floating algae covering much of the lake's surface, especially during the summer months, has diminished the appeal of the lake to swimmers and tourists.
In order to understand the processes driving the development of these algal mats, a comprehensive investigation of the interactions between sediment, water quality, phytoplankton and the hypolimnetic withdrawal was made. We will present the results of this systems analysis and the subsequent measures taken in order to inhibit the formation of the algal mats. These measures, which involved the application of lanthanum modified bentonite (LMB) to the lake, resulted in a significant reduction in the floating mats and demonstrate that LMB may serve as a suitable management tool in other comparable lakes in Austria.

40-O   Geo-engineering for clarity in Lake Groote Melanen.   _Guido Waajen [1] - Miquel Lürling [2]_

Department Knowledge & Advice, Water Authority Brabantse Delta, Breda, Netherlands [1] - Aquatic Ecology Ans Water Quality Management Group, Wageningen University, Wageningen, Netherlands [2]

Lake Groote Melanen is a shallow eutrophic lake (4.8 hectares) situated in The Netherlands. It is characterized by regular cyanobacterial blooms (Anabaena, Microcystis, Aphanizomenon) with a mean summer (April – September) cyanobacterial chlorophyll-a concentration of 73 µg L^{-1} (2012 – 2015) and maximum concentrations up to 300 µg L^{-1}. The mean summer concentration of total phosphorus (P) is 0.56 mg P L^{-1} (2012 – 2015) and the mean summer Secchi depth is 0.50 m (2012 – 2015). Submerged macrophytes are lacking. The fish biomass is 268 kg ha^{-1}, of which 78% consists of carp. The water residence time of the lake is on average 4.6 months. The total external P load is 3.8 mg P m^{-2} d^{-1}, of which 68% comes from two watercourses draining into the lake. Sediment P release of the lake is 2.8 mg P m^{-2} d^{-1}. The poor water quality hampers the recreational and natural values of the lake. Water management focusses on the realization of the clear water state dominated by submerged macrophytes, the reduction of cyanobacterial blooms and the establishment of a diverse fish community. Recovery of the lake is based on the shallow lakes theory with alternative stable states. Modelling derived critical P loads are 0.4 mg P m^{-2} d^{-1} for the transition from the turbid to the clear water state and 1.7 mg P m^{-2} d^{-1} for the transition from the clear to the turbid state. Recovery measures focus on the reduction of the external and internal P loads, on the reconstruction of the banks and on foodweb control. Measures targeting the sediment P release are based on an enclosure experiment in the nearby Lake Kleine Melanen, which has similar features and eutrophication problem as Lake Groote Melanen. In autumn 2015 most measures were executed: removal of fish, construction of a bypass for two draining watercourses, dredging of sediment, capping of the remaining sediment with sand and a P fixative (lanthanum modified bentonite, LMB) and the reconstruction of banks. In spring 2016 the water column will be stripped of P, algae and suspended solids by the combined usage of a flocculant (polyaluminiumchloride) and ballast (LMB), after which submerged macrophytes can be introduced. After the

establishment of the aquatic vegetation, the fish community can be adjusted. The first results of water quality monitoring will be presented and compared to the situation before recovery.

40-O   Evaluating phosphorus removal efficiency by iron magnetic microparticles with special consideration of chemical interferences in a context of lake restoration.   *Ana Funes*

Instituto del Agua, Universidad de Granada, Granada, Spain

Enrichment of aquatic ecosystems by phosphorus (P) is considered the main cause of eutrophication. Iron magnetic particles (MPs) have emerged as a promising tool for a satisfactory P removal of inland waters. By using microcosm enclosures containing brackish water (6000 µS cm^{-1}) and natural surface sediment from an hypertrophic aquatic ecosystem (Honda lagoon, in the southeast of Spain), this study assessed the effects of adding MPs on water quality, with special focused on P concentrations in water column and in the sediment. In the experiment, two different treatments (85:1 MPs: P$_{Mobile}$ molar ratio) were considered: T-W: where MPs were applied above the surface layer of water and T-S: where MPs were added directly above the sediment. After 24 h of contact time, P-loaded MPs were removed from the system by using a specially designed magnetic device. Physico-chemical parameters were monitored weekly for 85 days. Microcosms amended with MPs (both treatments) exhibited an average reduction of 68% in DIP concentrations in the water column compared to control for a 71-days oxic period, and of 80 % for a 5-days anoxic period. Reactive silicate (Si) concentrations were also decreased more than 50% on average for both periods in T-S and T-W treatments compared to control whereas dissolved organic carbon (DOC) concentrations were only reduced to 15% after 24 h of MPs addition, but equally indicating a possible interference of Si and DOC in P removal efficiency by MPs. The average 45:1 DIN:DIP molar ratio for the whole monitoring period (a revealing indicator of nutrient availability for primary production) exceeded well above the 16:1 Redfield ratio, pointing out a potential P limitation in microcosms treated with MPs. Sedimentary P fractions such as P bound to humic substances (P$_{Humic}$) or easily degradable organic P (Org-P$_{Labile}$) were significantly reduced to 22% and 12%, respectively in T-S compared to control. Recovery of MPs by the magnetic device was much lower for T-S (31%) than for T-W (90 %). In conclusion, T-W can be regarded as a suitable treatment to ensure the effectiveness of P export (in water and sediment) and the convenience of the technique by reusing the recovered MPs.

40-O   A microcosm experiment for testing biological effects of magnetic microparticles addition for phosphorus removal in eutrophic waters: the case of phytoplankton community.   *Ana Isabel Del Arco Ochoa, Inmaculada Álvarez-Manzaneda, Ana Funes, Inmaculada De Vicente*

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Successful remediation tools to reverse eutrophication are based on: (i) a decrease of phosphorus (P) external inputs from the watershed; (ii) an increase in P retention in lake sediment and (iii) an increase in P export from the aquatic ecosystem. Focusing on in-lake strategies (reduction in P concentration in both water column and in the sediment), recent studies have suggested the convenience of using magnetic microparticles (MPs) as a promising sustainable and effective eutrophication remediation tool. The present study is part of an interdisciplinary microcosm experiment aiming to assess chemical and biological changes in water column and in lake sediment after adding MPs for trapping P. In particular, our specific goal was to explore potential toxic effects on phytoplankton community. Microcosms (40 L water volume and 6600 cm^3 of sediment from Adra laggon, Southeast Spain) were stabilised outdoor. The experiment (which lasted for 85 days) was designed following a factorial design (n=5) with three levels of MPs concentrations (i.e. control; Treatment-Water, T-W; and Treatment-Sediment, T-S). In both treatments (T-W and T-S), MPs were added at a 1.4 g MPs/L concentration based on sedimentary P pool concentration but they simulated two different restoration scenarios: 1) T-W: MPs addition at the water surface being technically easier but meaning longer plankton exposition time, and 2) T-S: MPs addition at the sediment surface what would be technically problematic but it reduces contact time with planktonic biota. Phytoplankton abundance, species composition, richness and Chlorophyll a (Chl *a*) concentrations have been used as biological indicators. During the experiment, physical-chemical (pH, temperature, dissolved oxygen concentration and conductivity) and chemical variables (total P, phosphate, total nitrogen, nitrate, nitrite, ammoniun, silicate and dissolved iron) were recorded. Our results have shown that in terms of MPs retrieval efficiency, it was much higher in T-W (91%) than in T-S (32%). As it was expected, after MPs application, P concentrations in lake water were lower in the treatments than in the controls. The main concern was Fe dissolution from MPs for its

potential toxic effects, however, Fe did not dissolved during the aerobic period and only punctually (< 0.125 mg Fe/L) in the anoxic period. In fact, phytoplankton community did not show any differences between controls and treatments neither in abundance, richness, Chl *a* or community structure. Nevertheless, there are two meaningful qualitative differences on an eutrophication context: lower Chl *a* concentrations over the whole experiment in treatments compared to controls, and a decrease of cyanobacterias in specific times on treatments (*Microcystis sp.*). As a conclusion, MPs do not appear to have toxic effects on phytoplankton and arise as a realistic tool against eutrophication due to its P removal capacity and recovery from the water bodies.

40-O   Geo-engineering treatments: any impact on lake ecosystems?   *Fabrizio Stefani, Laura Marziali, Diego Copetti*

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The use of geo-engineering materials to control phosphorus release from bed sediments in lakes is increasing worldwide. The premise is that by controlling internal P loading the ecological effects of eutrophication can be rapidly reversed. The efficacy of these approaches in reducing the nutrients loads has been demonstrated in many cases and environmental conditions, and, similarly, the potential toxicity due to the input of relevant quantities of the key elements has been explored. Nevertheless, many potential issues are still partially known and predictable, especially on a long term scale, involving different ecological and trophic levels.

This presentation aims at providing a survey of these possible negative effects at different temporal scales. At this regard, an extensive review of published works on this topic has been done, enlightening the scarcity of long term monitored study cases and the uncertainty still existing on many aspects of lake recovery. Indeed, possible impacts derive from a wide set of factors or synergies and interactions with other preexisting sources of pressure. Starting, for instance, from a direct toxicological effect of the introduced elements or impurities, to bioaccumulation, to physical alterations of habitats, or physical impairments to organism functions to negative interaction with exotic species.

The control and identification of all these potential impacts is fundamental in the perspective of an ecological risk assessment procedure, especially when considering that the final aim of geo-engineering applications may be the achievement of the "good ecological status", thus implying the restoration not only of the chemical state, but also of aquatic communities such as phytoplankton, fish or macrophytes. Suggestions for ecological risk assessment for geoengineering treatment of lakes are finally proposed basing on the obtained conclusions.

40-O   Inactivating phosphorus in hypertrophic lakes – in a water or in sediment. "Proteus" can do it directly in sediments, but for how long, and what next.   *Ryszard Wiśniewski*

Department of Hydrobiology, Kazimierz Wielki University, Bydgoszcz, Poland

A common problem in hypertrophic lakes are blooms, often dominated by Cyanobacteria. Intense blooms usually end with mass dying of algal cells. This leads to the oxygen deficiency, mass death of fish, and release of cyanobacterial toxins. Main reason for blooms is phosphorus entering lake from its catchment area and accumulating in its sediments. The most effective method to deal with this problem is inactivation of phosphorus. In most cases, this is done through application of coagulants onto, or below, the water surface. The assumption is that amorphous coagulant flocs bind phosphate from water which, as it settles down, creates uniform, solid layer on the sediment's surface, which prevents phosphorus release. In reality, due to its very fragile structure, and low negative buoyancy, such layer can form only in very calm water. Even small water dynamics can prevent a uniform settlement of coagulant. Further, benthic organisms activity or gas bubbles released from the sediment can cause its partial redistribution. In case of intense sediment resuspension, redistribution of isolating layer can be substantial.

PROTE-FOS method, and designed two-module "Proteus" vessel blocks phosphorus in the sediment. Its principle is similar to that proposed by Ripl (1976). The similarity lies in the simultaneous air, and coagulant addition to the sediment. The main difference between them is that with PROTE-FOS one relies on the initiation of intensive, yet controlled, resuspension of the top layer of sediment, and on the application of coagulant at a precisely determined depth. Both, resuspension and coagulation, take place inside underwater unit of the "Proteus" device, allowing to monitor and keep parameters at values required to achieve optimal coagulation outcomes.

"Proteus" surface module: is powered by two engines, allowing vessel's forward and reverse movement;   can carry up to 3 tons of chemical substances, dosing them in a precisely controlled manner; pumps air into the bottom

sediment to the required depth, oxygenating it and triggering its re-suspension; it navigates across the reservoir monitoring its bottom; the vessel's position is reported very accurately (maximum error: 3 to 5 cm); controls its underwater module; its three computers allow it to work in three modes (automatic, half-automatic and manual). Underwater module is responsible for: the provision of information about its location versus the sediment; the triggering of controlled re-suspension of sediment inside its bell-shaped form; the oxygenation of bottom sediment; the dosing of chemical substances which bind the sediment phosphorus, and the coagulation and re-sedimentation after chemical substances have been applied.

Inactivation made in three lakes gave very good results. Concentration of phosphate blocked in sediments increased substantially. But to what concentration the load is safe for ecosystem in case of extremal resuspension?

40-O   Eutrophic lake remediation by using natural dolomite to immobilize dissolved phosphorus from water and diffusion from sediments.   *Boris Constantin, Rosa Galvez-Cloutier, Mellie Letheux, Olivier Zanette*

Civil Engineering And Water Engineering Department, Laval University, Quebec, Canada

Excessive nutrient release, mainly phosphorus, from domestic and agricultural sources accelerates water eutrophication in river and lakes, which causes algae blooms such as cyanobacteria, oxygen depletion, production of cyanotoxins and fish mortality. This leads to water uses loss and poses risk to human health through direct contact and water or fish consumption. External nutrient loading reduction is not always sufficient and in-lake remediation action may be required to improve water quality and becomes essential when drinking water sources are at risk. Employing geomaterials as reactive media (i.e. dolomite, calcite) to buffer water pollution is becoming an option in last years because of recent studies and demonstrations that they are efficient, low cost, ecologic with minor or no potential impact on the environment, and physicochemically stable.

In the context of sustainable remediation of contaminated water bodies (both water column and sediments) this work investigates application of natural dolomite ($CaMg(CO_3)_2$) to immobilize phosphorus in eutrophic lakes. Fine-grained dolomite rock was tested to remove phosphorus by adsorption and co-precipitation in the water column while coarse-grained dolomite rock was tested as a subaqueous active capping of contaminated sediments to prevent phosphorus internal loading. Phosphorus immobilization was assessed using sediments incubation experiments with water and sediments from an eutrophic lake under aerobic and hypoxic conditions to simulate *in situ* conditions.

The results showed that adequate dosage of fine-grained and coarse-grained dolomite material enables to reduce phosphorus concentration up to 84 % and below the eutrophication limit level of 30 µg/L. Final values for pH, conductivity and alkalinity suggest that dolomite application may not cause adverse ecological effects. Fractionation of sediment phosphorus was assessed on unaltered sediments cores and on sediments cores after the incubation period. In the top 5 cm layer of unaltered cores , potentially mobile P accounts for 44 % of total phosphorus. After the incubation period mobile P decreased in all cores while Ca-bound P increased slightly when dolomite was applied. Overall these results suggest that dolomite is an effective geomaterial for P immobilization that can be used for lake eutrophication control.

40-O   Continuous alum dosing of a large eutrophic lake: the first ten years.   *Grant Tempero [1] - David Hamilton [1] - Nicholas Ling [1] - Chris G McBride [1] - Andy Bruere [2]*

School of Science, University of Waikato, Hamilton, New Zealand [1] - Lake Operations, Bay of Plenty Regional Council, Rotorua, New Zealand [2]

Alum (aluminium sulphate) can be highly effective in reducing lake trophic levels by sequestering phosphorus. Typically, lake management programmes utilise discrete bulk alum dosing, which may cause acidification and have significant toxicological effects if not carefully managed. This method can be especially problematic for large lakes with limited buffering capacity. One potential alternative is low-level continuous alum dosing of inflows. This approach is advantageous because dose rates can be adjusted in response to changes in lake trophic status or catchment nutrient loads, and it avoids the need for additional buffering agents. There are comparatively few published studies of continuous alum dosing and few report on both water quality and biological community effects. Alum dosing of a single inflow to Lake Rotorua (area 80 km^2, mean depth 11 m, alkalinity 8.3 mg L^{-1} CaCO$_3$ equivalent) in the central North Island of New Zealand was initiated in June 2006 in an attempt to reduce both internal and external phosphorus loading. The

average aluminium (Al) dose rate was 98.8 kg Al d^{-1} for the first year, before being reduced to 70 kg Al d^{-1} for the next three years. A second alum dosing plant was installed on a separate inflow in January 2010, increasing the average total lake dose rate to 217 kg Al d^{-1} for the following two years. Following observed improvements in lake water quality in 2012, the dose rate was reduced to 178 kg Al d^{-1} and is currently maintained around that level. Monitoring of lake water quality revealed that alum dosing was highly effective in sequestering phosphorus, since 2012 there has been a 70% reduction in annual average dissolved reactive phosphorus concentrations in the lake and a 56% reduction in total phosphorus concentrations, compared to the three-year average concentrations immediately prior to alum dosing. Lake water clarity has also improved and there has been a reduction in the frequency of algal blooms. Annual surveys of the alum-dosed inflows have found no significant effects on biological community abundance or structure. Some evidence of aluminium bioaccumulation was observed in the gills and hepatopancreas/liver of crayfish and fish downstream of the inflow dosing sites compared to upstream sites, but this does not appear to have affected the condition or abundance of these species. Low-level continuous alum dosing of lake inflows appears to be a viable approach for the restoration of large lakes with low buffering capacity. However, the effects of long-term alum dosing are unknown and reductions in external nutrient loads will be required if alum dosing is to be discontinued in the future.

40-O   Geo-engineering for eutrophication management.   *Miquel Lürling [1] - Maíra Mucci [1] - Frank van Oosterhout [1] - Guido Waajen [2]*

Aquatic Ecology & Water Quality Management Group, Wageningen University, Wageningen, Netherlands [1] - Waterboard Brabantse Delta, Breda, Netherlands [2]

The Netherlands does not include standing water bodies smaller than 50 ha in their Water Framework Directive ecological status reports to the E.U. Nonetheless, those small waters often lay in the immediate vicinity of urban settlements and are the prime surface waters humans and animals have most intense contact with, but are also suffering severely from anthropogenic pressures. Consequently, many experience regular cyanobacterial blooms.
Our aim is to increase awareness of the vital importance of these waters to societies and in biogeochemical cycling, to elucidate the eutrophication issues and to develop system analysis based, site-specific solutions. In the latter, particularly geo-engineering techniques can provide needed extensions of the tool-box with curative and preventive measures to manage eutrophication.
In this presentation, we will provide examples of system analysis based whole lake experiments using a low dose flocculent and solid phase P-sorbent (lanthanum modified bentonite) that clearly demonstrate lakes can be moved from an eutrophic to an oligo-mesotrophic state and kept in the desired state for years. We will also present pond experiments to counteract nuisance eutrophication symptoms that demonstrate the importance of the system analysis in choosing the most promising set of management measures, yet keeping a do-nothing as option. In two of three urban ponds the system analysis and additional experiments yielded promising results for a set of in-pond measures targeting nutrient rich sediment and reshaping the biological make-up combined with reduced external loading, whilst for the remaining pond the external nutrient load was such high that all in-pond measures would be futile. Our multi-year pre- and post- application monitoring of the lakes and the ponds underpins the importance of such monitoring to gain better understanding of the treatment effectiveness and occurrence of unforeseen side effects.
In situations where reduction of external nutrient load is not feasible, flock and sinking cyanobacteria out of the water column can still provide effective, cheap, easy to apply and safe measures to mitigate nuisance eutrophication symptoms. Particularly using local materials as ballast strongly reduces costs that allows wide scale repeated application bringing immediate relief.
Geo-engineering approaches provide powerful supplements to existing catchment- and biomanipulation measures for eutrophication management.

40-O   The effects of capping with sand and aluminium hydroxides in a Dutch shallow lake.   *Leonard Oste, Gerlinde Roskam, Dick Bakker, Jack Hemelraad*

Deltares, Delft, Netherlands [1] - Geotrema, Gouda, Netherlands [2] - Waterboard Schieland En De Krimpenerwaard, Rotterdam, Netherlands [3]

Lake restoration often requires a decrease of the external nutrient loading. However, if the external loading has been reduced successfully, also reducing the internal loading is a critical success factor for lake restoration. Lake restoration

by capping the sediment is one of the possibilities to reduce the internal loading. In most cases a thin layer of phosphate binding agents like Phoslock, alum, poly aluminium chlorides, iron chlorides or waste materials was applied (chemical capping). Another possibility is capping with a thick (20-50 cm) layer of sand or soil (physical capping). Both methods influence the internal loading, but in a different way.

Work undertaken: Lake Bergse Plassen, Rotterdam (NL), consists of two parts connected by a small canal. In 2001, the western lake was covered with 25 cm of sand. Ten year after the western part was capped, also the eastern lake was capped, but then a 20 cm sand layer was applied on top of the sediment and part of the eastern lake got a combined physical-chemical treatment: polyaluminium chloride was added to the lake directly before capping with sand, resulting in a chemically reactive layer of aluminium hydroxides between the sediment and the sand. Surface water quality and pore water quality were monitored. Sediment cores were taken before and directly after treatment, and also after 2 and, in the western lake, after 10 years. Supporting laboratory experiments have been performed: a) diffusion experiments in undisturbed sediment columns, and b) sand + aluminium hydroxide columns flushed with a continuous flow of phosphate solution.

The water quality in Lake Bergse Plassen has improved strongly, but this was the result of a combination of measures. We focused on the effect of capping. A top layer consisting of only sand strongly changed the pore water profiles in the field compared to the original sediment, suggesting that a sand layer does not only provide a physical barrier but also alters the chemistry. The dissolved iron concentrations in the sand layer were significantly higher, also 10 years after capping, which might have a beneficial effect on the binding of P when the iron is transported to the overlying surface water where it is oxidised to iron hydroxide.

The laboratory experiments revealed that a sand layer reduced the phosphate flux significantly, but that sand/Al-hydroxide was significantly more effective. The pore water profiles in the field cores showed that the addition of Al-hydroxides between the original sediment and the sand layer reduced the $P_{porewater}$ at the sediment-sand interface strongly compared to the area that was only capped with sand. The aluminium addition did not affect the pore water profiles in the sand layer very much.

40-O   Manipulating nutrient limitation using modified local soils: a case study at Lake Taihu (China).

Gang Pan [1] *, Lijing Wang* [2]

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Nutrient limitation dictates the strategies and costs involved in eutrophication management. An attempt to manipulate nutrient limitation/cycling was studied in comparable whole ponds in Lake Taihu using geo-engineering materials of chitosan modified local soil (MLS) in October 2013. Approximately 20 kg MLS were sprayed onto the whole water pond (400 m^2) and *Chlorophyll-a* (*Chl-a*) concentration was decreased from 42.49 to 17.53 µg L^{-1} within 2 hours. In the following 15 months, *Chl-a* remained less than 20 µg L^{-1} in the treatment pond, compared to the average of 35.71 µgL^{-1} in the control pond. In situ nutrient addition bioassay experiments indicated that the nutrient limitation was shifted from N+P co-limitation to P limitation from October 2013 to March 2014, where phytoplankton biomass and growth rates showed no increase by adding nitrogen (N) but significant increase by adding phosphorus (P) in the treatment pond, meanwhile, either N or P addition led to phytoplankton growth in the control pond. In the summer 2014, a strong N limitation was observed in the treatment pond, however, the maximum biomass and growth rate of phytoplankton were 2.23 and 1.65 times lower than the control pond under adequate N addition. The control pond remained *Cyanobacteria*-dominated state, while *Chlorophyta*, *Bacillariophyta*, *Cyanobacteria* and other algae coexisted in the treatment pond. The upper limiting concentration of DIN was enhanced from 0.8 to 1.5 mg N L^{-1} and SRP from 0.1 to 0.3 mg P L^{-1} compared to the control pond. This study indicates that nutrient limitation in some waters can be manipulated by changing P, N, and phytoplankton composition and their ratio using MLS technology, which may provide new strategies for eutrophication mitigation.

40-O   Ecological restoration of Lake Orta (Northern Italy), one of the largest world's acidified lakes.

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With a surface area of 1814 ha, a depth of 143 m, and a volume of 1.29 km^3, Lake Orta, is among the largest lakes in Italy. Lake Orta also has a disturbing history of severe industrial pollution, and, given its volume, it can be considered one of the largest lake to have undergone acidification in the world. The fish fauna, the biotic component most visible to the public, was heavily damaged and any potential recovery was compromised by the construction of impassable dams along the lake's outlet, dams which prevented any possible natural recolonization from the neighbouring Lake Maggiore and River Po Basin.

Beginning in 1926, the lake was polluted by ammonium and copper sulphate from a rayon factory. So serious was the algicidal effect of copper salts, that the whole food web of the lake, including its plankton, benthos and fish fauna, was seriously damaged within a few years (Monti, 1930). The situation then worsened in three ways. In the 1950s, Cu, Cr, Ni and Al discharges from metal plating and manufacturing industries in the watershed contaminated the lake with additional metals, and the oxidation of ammonia both consumed profundal oxygen and inexorably acidified the lake. Indeed the pH of the lake had fallen to 3.9 by 1985. The recent situation is Lake Orta has improved dramatically. The water quality of the lake has been restored, both because of reduced pollutant inputs and a massive liming intervention carried on in 1989-1990. However, still after two decades, the fish community is far to be fully restored. Indeed recent fish investigations have shown the absence of truly pelagic fish species, such as European whitefish *Coregonus lavaretus* and landlocked shad *Alosa agone*, typical profundal cold water species such as burbot *Lota lota* and arctic char *Salvelinus alpinus*, and migratory ones such as marble trout *Salmo marmoratus*, which were abundant in the years predating the lake pollution and dams construction. According to the recent picture of the fish community, priorities for ecological restoration were set and first restoration activities were started. Artificial reproduction of European whitefish began in January 2014 and ca. 2 millions of pre-fed larvae reared in illuminated cages have been introduced in the lake in the last two years. The status of whitefish population was not quantitatively assessed still, but adult whitefish were already captured during preliminary sampling activities done by anglers. Data of somatic growth and body condition of whitefish are satisfactory and similar to the neighbouring Lake Maggiore indicating that the environment of Lake Orta provides suitable conditions for a successful re-establishment of pelagic fish species.

40-O   Predicting sediment contaminant flux: why accurate baz measurements are important (and not your only concern!)   *Joseph Germano*

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Sediment Profile Imaging (SPI) is an innovative "optical coring" technique that takes an undisturbed cross-sectional image of the upper 20 cm of sediment. It has been used extensively in the marine environment for the past 30 years and has just started being used as a monitoring tool in freshwater environments for both dredging and dredged material disposal studies as well as contaminated sediment investigations.

Selection of acceptable sediment remedial alternatives for contaminated sediment sites are strongly influenced by results from flux models that look at the sediments as a source of contaminants to the water column. The flux rate is highly dependent on the depth of the biologically activity zone (BAZ), which is one of the major drivers for geochemical exchanges across the sediment-water interface. Published studies on the burrowing depth of freshwater infauna show the majority of invertebrates are restricted to the upper 10 cm of sediment, with most activity in the top 5 cm. Examples from several SPI surveys in both river and lake settings from Canada, Italy, and the United States will demonstrate why one should not rely solely on average BAZ estimates derived from literature values. Our results have frequently shown that the BAZ was much greater than published averages, and in many cases, site-specific physical or geochemical processes were equally important as a sediment mixing force. Using rapid reconnaissance technology such as SPI now makes it possible to collect site-specific information for cost-effective resource management decisions.

40-O   Restoration of two chinese subtropical shallow eutrophic lakes: special focus on the interactions between fish and submerged macrophytes.   *Jinlei Yu, Zhengwen Liu, Baohua Guan, Feizhou Chen, Kuanyi Li, Yaohui Hu, Yaling Su, Yingxun Du, Hu He, Yongdong Zhang, Erik Jeppesen* [1]

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Abstract: 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 of fish as well as the potential role of grass carp (*Ctenopharyngodon idella*) in controlling relative composition and biomass loss of submerged macrophytes. Omnivorous fish (*Hemicculter 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 (where grass carp dominated the fish community in both abundance and biomass) through stronger selective feeding on *V. spinulosa* and *C. demersum* than on *M. spicatum*. Thus, in Chinese subtropical shallow 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.

40-O   Restoration of a eutrophic hard-water lake by applying an optimum dosage of poly-aluminium chloride: reasons, results, problems.   *Peter Kasprzak*

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Lake Feldberger Haussee (NE Germany) was polluted by the effluent of a sewage treatment plant. Until 1980 nutrient input was 1.9/11.5 g TP/TN m^{-2} yr^{-1}. As a result, the lake developed into a hypertophic ecosystem and had largely lost its recreational value. In 1980 the sewage discharge was stopped decreasing the loading by approximately 90%. Because of vast amounts of phosphorus stored in the sediment, the Haussee until 1985 remained highly eutrophic with a TP concentration of ca. 1 mg L^{-1}. To accelerate recovery, biomanipulation has been applied from 1985 – 2002 but was successful to only a minor extent. Eventually, due to sediment sequestration and discharge to downstream lakes, the TP spring maximum (2006 – 2010) had dropped to 0.112 -0.078 mg L^{-1}. However, given the trend it was plain that it would take another 10 – 15 years until the concentration should approach the desired mesotrophic level. Thus, it was suggested to treat the lake using aluminium salts as precipitant. To ensure good water quality, a target concentration of ≤ 0.035 mg TP L^{-1} had been intended. The objective was to achieve this result by optimising the amount of aluminium being applied. As a prerequisite, the status of the lake was carefully studied, external phosphorus loading and the amount of mobile phosphorus stored in the sediment being of specific interest. Laboratory experiments and field observations eventually resulted in a dosage of 27 g Al m^{-2} (Al/P 12). Subsequent to the treatment in April 2011, changes of prime water quality parameters showed two opposing trends. TP concentration immediately dropped below the restoration target (0.025 mg L^{-1}). Primary production and phytoplankton biomass declined. However, water clarity did not improve for another four years. The most likely reason for the delay was the structure of the phytoplankton community. It was dominated by cyanobacteria having the potential to trigger intensive calcite precipitation and thus impair transparency. For yet not fully understood reasons, in spring 2016 the cyanobacteria suddenly disappeared and transparency increased significantly. We speculate that the modification of the algal community shifted the proportion of assimilation and respiration in favour of the latter. This allowed an increase of free CO_2^* (dissolved CO_2 & carbonic acid) which shifted the carbonate-bicarbonate equilibrium thus halting the formation of calcite crystals. Also, the phytoplankton, now represented by small readily ingestible taxa, promoted a flourishing *Daphnia* population inflicting heavy grazing losses, and thus enabled a clear water phase in June 2015 (4.20 m). Summarising we conclude that a drastic decrease of phosphorus availability in concert with structural and functional changes of the plankton community, though delayed by for years, eventually improved the water quality of the Haussee significantly. The lake is now in a mesotrophic status, well in accordance with the aim of the restoration project.

40-O Phosphorus sorption and supply from eutrophic lake sediment amended with thermally-treated calcium-rich attapulgite and a safety evaluation. _Hongbin Yin_

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Modified clays are being increasingly used as P-inactivation agents for lake eutrophic control. However, the interaction of P with these material amended sediments still remain unclear. This study investigates the P sorption and supply from the thermally treated calcium-rich attapulgite amended eutrophic lake sediments as well as the ecological safety of material addition. The results indicated that P sorption on material amended sediment can be well fitted by a modifed Langmuir model. Material addition can greatly enhance the P sorption capacity of lake sediment and lower the zero equilibrium P concentration (EPC_0), which can turn lake sediment from a source to a pool. P sorption on raw and material amended sediment generally decreases with an increase of the water pH value. But material amended sediment still can adsorb a large amount of P even in very akaline conditions resulting from algal blooms. Furthermore, P sorption on amended lake sediment was less influenced by NO_3^- and HCO_3^- than by SO_4^{2-} to a moderate degree and by SiO_3^- to a much larger degree. The results of diffusive gradients in thin films (DGT) measurement indicated the ability of P supply from lake sediment was largely inhibited by material addition. This was due to sediment mobile P had been transformed into stable Ca-P. A toxicity study indicated that material additions can increase pH value in lake sediment and can cause a toxic effect on benthic organisms when a large addition of material is involved, but this would be greatly attenuated in the field. The results of this study indicated that thermally treated calcium-rich attapulgite has the potential to be used as a P-inactivation agent for lake eutrophication control.

40-P First results of a water aeration experiment on a mediterranean hypereutrophic reservoir.

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In the Mediterranean region, freshwater is a scarce resource and climate change will strongly affect water availability, accompanied by increasing levels of eutrophication and abundance of cyanobacteria in lakes and reservoirs. Consequently, an adequate management of water resources and valid restoration actions are needed to adapt to future scenarios. With this aim, a water aeration experiment had been carried out in the Lake Bidighinzu (N-W Sardinia, Italy) in the period April 2014-October 2015. The main objectives were to verify reservoir answers, especially in terms of hypolimnetic oxygen (DO) and total phosphorous (TP) concentrations and phytoplankton (Chl_a_) trends, due to micro air bubles ($\emptyset \approx 2.2$ mm) action. Lake Bidighinzu is a hypereutrophic and warm monomitic reservoir that belongs to the Long Term Ecological Research-Italy network (LTER-Italy). The experiment preserved summer thermal stratification of the reservoir in the first year (April-October 2014) whereas did not allow summer thermal stratification in the second (April-October 2014). In 2015, DO did not arrive at the total anoxia, instead observed both in 2014 and in the LTER series. In parallel, the concentrations of TP, both in the first and second cycle of experimentation, were less high (about 216 mg P m^{-3} in 2014 and 164 mg P m^{-3} in 2015) than in the LTER series (305 mg P m^{-3}). Chl_a_, in the second period, peaked up to 434 mg m^{-3}, one of the maxima of the entire LTER series, due to a more intense cyanobacterial affirmation. To assess differences among periods (2014, 2015, LTER series) on environmental (temperature, TP, DO) and phytoplankton (Chl_a_) data a one-way analysis of similarities test (ANOSIM) was performed (probability percentages <0.03 were considered significant). The results showed significant differences among the periods compared to the variables considered (TP: Global R = 0.650; p = 0.1%; DO: Global R = 0.169; p = 1.5%; temperature: Global R = 0.198; p = 1.8%). No substantial differences were evident for Chl_a_ (Global R = 0.05; p = 15.6%).
The results suggest the necessity of continuation of the aeration experiment with micro air bubles in the Lake Bidighinzu, for the achievement of a state of optimal oxygenation of the hypolimnetic water since the winter months without impeding the summer stratification and to avoid Chl_a_ and cyanobacteria summer peak up. This experience could be extended to other reservoirs, characterised by a lower eutrophic status, waiting for sharper and faster remediation answers.

40-P   Testing possible toxicological effects of iron microparticles on a natural lagoon plankton community: a microcosms experiment.   *Inmaculada Álvarez-Manzaneda Salcedo [1] - Ana Isabel del Arco Ochoa [1] - Ana Funes Cabrerizo [1] - Francisco José Guerrero Ruíz [2] - Luis Cruz Pizarro [1] - Inmaculada de Vicente Álvarez-Manzaneda [1]*

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At present, because of human action is altering biogeochemical cycles, phosphorus (P) reserves are being depleted, while aquatic ecosystems suffer a P enrichment due to the translocation of this element. So actually, we are facing both crucial problems: (i) the depletion of P reserves for producing fertilizers and (ii) the eutrophication of aquatic systems. If we focus on restoration tools for controlling inland waters eutrophication, three different methods have been proposed: (i) a reduction in P external loading, (ii) an increase in P retention by the sediment and (iii) an increase in P export from the system. Among the most novel method proposed for combating eutrophication. The use of magnetic microparticles (MPs) is an innovative and promising tool for P removal from aqueous solutions and many advantages have been identified. However, before using them in a "whole-lake application", it is essential to assess their toxicological effects on aquatic biota. For this reason, a microcosms experiment was carried out with brackish water (6000 μS cm^{-1}) and sediment from an hypertrophic aquatic ecosystem (Honda lagoon, in the southeast of Spain) with the aim of evaluating the possible toxicological effects of iron MPs on plankton organisms. The experiment lasted for 85 days and two different treatments (1.4 g MPs l^{-1}) were considered: Treatment-Water (T-W), where MPs were added above the water surface; and Treatment-Sediment (T-S), where MPs were added at the upper sediment layer. After 24 h of contact time, MPs were removed using a magnetic system designed for this task. On a weekly basis, water samples (for chemical and biological analysis) were collected and physico-chemical parameters were measured (i.e. pH, conductivity, dissolved oxygen concentration and temperature). Our results have shown that dissolved iron concentrations were very low at both oxic and anoxic conditions. Organisms of each experimental unity were counted and identified. Multivariate techniques were used to assess the response of zooplankton at the MPs exposition. These community structural responses were compared to untreated controls. After 24 h of MPs removal, no significant differences (ANOVA test; p>0.05) in species richness, species diversity and total abundance was observed between control and treatments. As a conclusion, MPs are likely to do not cause any toxicological effect on zooplankton organisms. Then, the results of this study confirm the suitability of MPs as an ideal tool for removing P in eutrophic aquatic ecosystems.

40-P   Effect of pH and redox state on phosphorus adsorption maximum of modified clays and red soil.   *Maíra Mucci [1] - Natalia Noyma [2] - Marcelo Marinho [2] - Miquel Lürling [1]*

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Controlling eutrophication and mitigating cyanobacteria nuisance is considered a key challenge to water quality managers. Managing the direct influx of nutrients, however, has not resulted in the expected recovery from nutrient pollution in many lakes, ponds and reservoirs, due to in-lake biogeochemical and biological changes. Particularly, phosphorus (P) stored in and recycled from the sediments can delay recovery for many decades or even preclude it. To speed-up recovery and tackle this so-called internal loading issue, solid phase P-sorbents have gained attention as potential weapons against this worldwide problem. These products are amongst others modified or natural clays and soils that have the capacity to bind soluble reactive phosphorus (SRP) from the water column and to block SRP release from the sediment. The efficacy of such compounds may, however, be influenced by abiotic variables such as pH, redox state, DOC concentration or salinity. Thus, it is essential to test those products thoroughly on efficacy and potential side effects prior to application in the environment.

The first step in the sequence of upscaling experiments are laboratory studies that evaluate the maximum SRP adsorption capacity of the products at various conditions. In this study we tested the SRP adsorption capacity of modified lanthanum bentonite (Phoslock®), modified aluminum zeolite (Aqual-P™) and red soil (RS) from Funil reservoir (Brazil) at four different pH values (6,7,8 and 9), and also in anoxic condition. Hereto, standardized batch experiments were run with eight different SRP (0, 5, 10, 20 40, 80, 120 and 160 mg P L^{-1}) concentrations and a fixed amount of each

product (2 g L^{-1}). Phoslock$^®$ had the highest SRP adsorption capacity of 10.5 mg P g^{-1} at pH 6, while at higher pH values the adsorption capacity decreased by 26%. Similarly, the red soil had its highest P adsorption capacity at pH 6 (4.5 mg P L^{-1}) that decreased with increasing pH. In contrast, Aqual-P™ showed the highest P adsorption capacity at pH 9 (7.6 mg P g^{-1}), which decreased at lower pH. Under anoxia all compounds decreased their SRP-sorption capacity, Phoslock$^®$ to 5 mg P g^{-1}, Aqual-P to 5.9 and RS to 0.2 mg P g^{-1}. Although, SRP adsorption of red soil was lower than of the modified clays and further reduced under anoxia, its ease to harvest and low transport costs, can still render it a cost-effective alternative to the far more expensive, yet better performing, modified clays. Hence, further research on red soil performance in more natural conditions is recommended.

40-P   Amendment of oxygen and nutrient conditions in the deeps of Lake Vesijärvi by the introduction of epilimnetic water.   *Mikael Kraft* [1] *- Ismo Malin* [2] *- Kalevi Salonen* [3]

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Lake Vesijärvi in southern Finland suffered from municipal waste waters until the mid-1970s. The external nutrient load dramatically diminished after their diversion, but the lake still remained eutrophic and its deeps suffered from oxygen depletion. Deep-water anoxia frequently developed during winter and summer, and high nutrient concentrations resulted in harmful phytoplankton blooms. Various efforts to reduce the blooms have been established since the 1980s. These have included the removal of planktivorous fish to reduce the top-down control of zooplankton and introduction of oxygen by pumping oxygen-rich epilimnetic water into the hypolimnion.
An extensive long-term programme was begun in 2009 to prevent the development of anoxia in the deeps of the basin and to reduce the consequent release of nutrients from the sediment. To reach this goal oxygen-rich epilimnetic water is pumped into the deepest water layers to compensate for the oxygen consumed in respiration.
Results have been promising during the six years of operation. The hypolimnetic oxygen concentration during winter has remained continuously high. Instead, hypoxic or anoxic conditions have developed during summer at the end of stratification, but the duration of hypoxic conditions was markedly reduced and anoxia became only occasional.
No change was observed in epilimnetic total phosphorus (P) and nitrogen (N) concentrations, but these have stabilized and declined in the deepest water layers. Total nitrogen concentration in particular was markedly (20–50%) reduced by denitrification. However, the N:P ratio of the deeps still indicated phosphorus limitation.
Epilimnetic chlorophyll-a concentration and phytoplankton biomass were not greatly affected by the improvement of hypolimnetic oxygen conditions, albeit these are presently at their lowest level since the diversion of sewage waters. Cyanobacterial blooms have decreased, but phytoplankton biomass and species composition still indicate eutrophic conditions. Increased oxygen concentrations in deep water have led to a severalfold increase of bottom animal biomass in the profundal zone, thus providing more food for bottom-feeding fish.
One of the negative effects following the pumping of epilimnetic water into the hypolimnion was the eventual destruction of the cool water metalimnetic habitat of cool water fish before the end of summer stratification. The reduction of the density difference between the epi- and hypolimnion further increased the possibility of breakage of the stratification during summer, which can markedly increase phytoplankton biomass. Indeed, that was demonstrated during the cool summer of 2015.
The programme will be continued and based on our experience its implementation will be modified to reach the optimal water quality of the lake.

40-P   Growth inhibition of *Microcystis* cells by electrochemical treatment using dimensionally stable electrodes.   *Bong-seok Jeon* [1] *- Jisun Han* [1] *- Ho-Dong Park* [1]

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Microcystis cells and microcystins can be oxidized and inactivated by electrochemical treatment. Also, growth of *Microcystis* cells can be inhibited. In this study, we investigated the charge of electricity for removal and growth inhibition of *Microcystis* cells. The material of electrodes (Pt electrodes and Dimensionally Stable Electrodes) was compared. Also, the effect of the conductivity and flow rate of electrolytes were investigated. All treated samples were cultured using bioassay and investigated the growth of *Microcystis* cells.

The Dimensionally Stable Electrodes were more inhibited the growth of *Microcystis* cells than the Pt electrodes. The charge of electricity for the growth inhibition of a *Microcystis* cell was 1.0 C (coulombs), approximately, regardless of the conductivity and flow rate of electrolytes. The charge of electricity for removal and growth inhibition of the 4 L algal suspensions were 30×10^3 C and 1.6×10^3 C, respectively. Overall, electrochemical treatment for the water body in the initial period of cyanobacteria blooms could decrease energy cost.

40-P   The growth inhibition effect on cyanobacterial cells under oscillating mixing.   *Jisun Han* [1] - *Bong-seok Jeon* [1] - *Ho-Dong Park* [2]

Graduate School of Science and Technology, Shinshu University, Matsumoto, Japan [1] - *Faculty of Science, Shinshu University, Matsumoto, Japan* [2]

To investigate the effect on cyanobacterial cell growth of oscillating mixing, the laboratory and mesocosm experiments were conducted. The oscillating mixing device has two axes of horizontal and diagonal, and it was rotated by a motor connected above.

Four treatments were prepared in the laboratory experiments; 1 control (no mixing), 2 oscillating mixing, 3 magnetic stirrer and 4 common propeller. Optical density at 405nm and the intra- and extra-cellular microcystin concentration were measured to investigate toxin release by cell damage as well as the growth inhibition. Cell density was decreased in oscillating mixing, meanwhile it was increased in the other treatments. Moreover, the optimal rotational speed on the growth inhibition of *Microcystis* cells was 150 rpm and it correspond to 2.5 Hz when converted into frequency. Interestingly, the remarkable microcystin release was not observed in oscillating mixing compared with other treatments.

In the mesocosm experiment, it was selected two ponds which have similarities of water quality and dominant species. One is control (no mixing) and the other is equipped with the oscillating mixing device. Cell density and the species composition as well as water quality were measured to investigate the effect of oscillating mixing. Cyanobacterial cell density in treated pond was similar to control pond before the operation of the oscillating mixing device. However, cell density was decreased after operation in treated pond, it was a hundredfold lower than control pond at 54 days after the operation.

Based on the results of the laboratory and mesocosm experiments, it concluded that oscillating mixing caused the growth inhibition of cyanobacterial cells, however, did not cause the release of microcystin. Therefore, the oscillating mixing device would be useful to remove toxic Microcystis cells without the toxin release.

40-P   Verification of phosphorus release suppression effect using magnesium oxide in lake sediments.   *Saori Nomura*

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The occurrence of cyanobacterial blooms are strongly influenced by nutrients such as nitrogen and phosphorus in eutrophic lake. In particular, internal phosphorus loading is mostly caused by anoxic sediment in a eutrophied lake. Therefore, phosphorus removal and/or inactivation is an effective approach for prevention of eutrophication of lakes. It is known that phosphate could be precipitated with magnesium in the form of struvite, $MgNH_4PO_4$, or ammonium magnesium phosphate compounds. In this study, we investigated the suppression effect of magnesium oxide (MgO) on phosphorus release in anoxic sediments.

The sediments were collected at moats of the castle Matsumoto (Matsumoto, Japan) in June, 2015. The concentrations of dissolved oxygen and PO_4-P were measured in the samples of sediment with/without MgO. The PO_4-P concentration in the suspension without MgO gradually increased. However, the PO_4-P concentration in the suspension with MgO decreased by 90%. Therefore, it could be concluded that magnesium oxide has the suppression effect on phosphorus release in anoxic sediments due to the compound formation of MgO and phosphorus and/or the adsorption of phosphorus on the MgO surface.

40-P The effect of pulverising aeration on changes in the oxygen, nitrogen concentrations and electrolytic conductivity in waters of Lake Starzyc and Lake Resko. *Małgorzata Gałczyńska [1], Piotr Wesołowski [2], Adam Brysiewicz [2], Marta Buśko [1]*

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Bad ecological status of lakes in Europe necessitates the need for their restoration. Recently, the most commonly applied method of water restoration is aeration of near-bottom waters. There are several technical solutions of hypolimnion aeration without disturbing thermal stratification, e.g. the use of pulverising aerator (the wind turbine starts operating at the speed of $2 \ m \cdot s^{-1}$). This device draws deoxygenated near-bottom waters and returns it back to hypolimnion after oxygenation. The aim of this paper was the analysis of the variability of concentration of oxygen and nitrogen compounds, and electrolytic conductivity in waters of Lake Starzyc (LS) and Lake Resko (LR).

Both water reservoirs are characterised by, among others, similar area of water table (LS – 59,2 ha and LR – 50,7 ha), and comparable maximum (respectively: 6,1 m and 5,0 m) and mean depth (both – 2,7 m). The water samples were collected from April to October over the period of 6 years in the surface water layer (0.5 m from the water table) and near-bottom (1.0 m from the bottom). The samples were analysed for O_2 concentration, electrolytic conductivity (EC) and concentration of $N-NO_3^-$ and $N-NH_4^+$. The results were statistically analysed. Two periods were selected for comparative analysis: the year 2005 and the years 2008÷2010. Due to the absence of statistically significant differences in concentration of $N-NH_4^+$ between all measuring points, and $N-NO_3^-$ between most measuring points, the analysis was limited to only 3 measuring points in LS and 4 measuring points in LR.

Mean concentration of the analysed water quality indices for LS was: O_2 – 5,1 $mg \cdot dm^3$, $N-NO_3^-$ – 0,09 $mg \cdot dm^3$, $N-NH_4^+$ – 0,33 $mg \cdot dm^3$, EC – 351 $\mu S \cdot cm^{-1}$, and for LR: O_2 – 6,2 $mg \cdot dm^3$, $N-NO_3^-$ – 0,29 $mg \cdot dm^3$, $N-NH_4^+$ – 0,33 $mg \cdot dm^3$, EC – 207 $\mu S \cdot cm^{-1}$. It was found that concentration of $N-NH_4^+$, $N-NO_3^-$ and O_2 in the measuring point in the vicinity of aerator did not differ from the values of the indices recorded in other measuring points in the lakes, which reflects the comparable abiotic conditions characteristic for the analysed waters. Increased concentration of O_2 in water did not result in increased electrolytic conductivity only in the surface layer of LR. In LS, increased concentration of O_2 and slightly decreased concentration of $N-NO_3^-$ were observed in the period 2008÷2010 in comparison to 2005. The recorded variability is most likely due to decreased supply of organic matter to the lake as well as phosphorus inactivation conducted in the water of the lake. In LR, both in the surface as well as in near-bottom layer, there were no changes in O_2 concentration in the analysed periods. Decreased concentration of $N-NO_3^-$ in the period 2008÷2010 as compared to that recorded in 2005, may reflect the conditions of limited agricultural production in the catchment basin of the lake and well-structured wastewater management. So far, restoration activities conducted in the two lakes under analysis have not produced positive results.

41. CAUSES AND CONSEQUENCES OF ECOLOGICAL CHANGE IN LARGE LAKES OF THE WORLD

41-O   Decadal-scale changes in surface chlorophyll concentration and primary production in lakes huron and michigan derived from satellite observations.   *Barry M. Lesht* [1] *- Richard P. Barbiero* [2] *- David M. Warner* [3] *- Glenn J. Warren* [4]

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Time series of chlorophyll-a estimates derived from observations made by ocean-color monitoring satellites since 1998 show that substantial changes have occurred in the phytoplankton cycles of lakes Michigan and Huron, the second and third largest by volume of the Laurentian Great Lakes. In both lakes, the spring phytoplankton bloom, which had been the primary feature of the annual biological cycle, began to diminish in 2002 before disappearing completely within a few years. Along with the declines in phytoplankton biomass suggested by the changes in chlorophyll concentration, model-estimated annual primary production declined by approximately 30% (Michigan) and 40% (Huron) after the disappearance of the spring bloom. Although these changes generally have been attributed to the filtering activities of invasive dreissenid mussels, which first appeared in the lakes around 1990, the similar biotic responses of lakes Huron and Michigan despite differences in the degree of mussel infestation, suggest that other factors cannot be ignored. For example, recent studies show that total phosphorus concentration, which is independent of mussel density, may be an even more important explanatory variable. Here we use satellite observations to examine detailed changes in both space and time of the chlorophyll concentration and primary production in both lakes. Using daily concentration fields estimated by applying a Gaussian-weighted averaging to adjacent images we calculate daily temporal and spatial anomalies (relative to the long-term mean) and integrate these anomalies over different time scales (monthly, seasonally, annually) to explore how the detailed patterns of production (using chlorophyll concentration as a surrogate) have changed over the period of record.

41-O   A comparison of recent changes in nutrients and the lower food web in Lake Huron and Lake Michigan: synchronous changes, dyssynchronous causes?   *Richard Barbiero* [1] *- Barry Lesht* [2] *- Glenn Warren* [3] *- Lyubov Burlakova* [4] *- Lars Rudstam* [5]

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The Laurentian Great Lakes of North America, containing approximately 21% of the world's surface fresh water, form the largest group of freshwater lakes on Earth. Lake Michigan and Lake Huron, the second and third largest lakes in this system by volume, are connected hydrologically by the Straits of Mackinac, and thus constitute a single hydrologic unit. Both lakes have been subject to substantial anthropogenic influences in the past 50 years, notably nutrient controls to reduce phosphorus loading, and the arrival of invasive species including the spiny water flea (Bythotrephes longimanus) and dreissenid mussels (Dreissena polymorpha, D. rostriformis bugensis). Despite their long residence times (62 and 22 years, respectively), both lakes have undergone substantial, rapid changes in recent years, including dramatic reductions in the size of the spring diatom bloom, increases in water clarity, declines in populations of the benthic amphipod *Diporeia*, and a shift in summer crustacean communities away from cladocerans towards calanoid copepods. While some of these changes have occurred in parallel, in other cases important distinctions have been apparent in both their timing and magnitude. For example, shifts in crustacean communities have been more sudden and pronounced in Lake Huron, but have not resulted in the absolute increases in biomass of calanoid copepods that have been seen in Lake Michigan. And while filtration by dreissenid mussels has been posited as a causal factor in the lower food web shifts in

both cases, dreissenid population expansion has been much more rapid in Lake Michigan, where population densities vastly exceed those in Lake Huron. Thus it is not clear if the same causal mechanisms are at work in the two lakes. Here we'll compare the trajectories of nutrient and lower food web changes in lakes Michigan and Huron, particularly in the context of potential causal mechanisms, in an attempt to determine the extent to which the two lakes may or may not be responding to similar drivers.

41-O   Zooplankton community regulation in Lake Ontario: inferences from spatial distributions.

Lars Rudstam [1] *- Warren Currie* [2] *- Timothy Johnson* [3] *- Brian Weidel* [4] *- Kelly Bowens* [2] *- James Watkins* [1] *- Matthew Paufve* [1]

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Zooplankton abundance and biomass were measured across Lake Ontario during the CSMI year of 2013 by several agencies around the Great Lakes (NYSDEC, OMNRF, USGS, DFO, and EPA). This data was collated at Cornell University into a coherent database available to all participants. Here we use the observed spatial distribution across the lake and across seasons to investigate hypotheses for the regulation of zooplankton species composition in the lake. We also compare the 2013 data with trends through time. Community structure in 2013 was returning to the structure observed in the late 1990s early 2000s with a dominance of cyclopoid copepods and cladocerans. This coincide with a decline in the predatory invasive spiny water flea, *Bythotrephes*, in 2013. Such correlations support the hypothesis that the species composition is regulated by *Bythotrephes* predation. However, spatial distribution showed the same changes in species composition occurring across the lake regardless of the spatial patterns in *Bythotrephes* abundance. We discuss these inconsistencies in the spatial and temporal data in light of other possible explanations that could be consistent with both patterns, such as nutrients, primary production, light regimes, and alewife abundance.

41-O   Trophic cascading effects of invasive zebra mussels and mysids on the planktonic food-web of Lake Champlain, USA.

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Freshwater lakes provide ideal habitat for invasive species, such as the Zebra Mussel, that may weaken their ecological integrity by altering food web structures and dynamics. Twenty three years of records of population dynamics of invasive Zebra mussels and native Mysids as well as native zooplankton (Rotifers, Cladocera, and Copepods) in Lake Champlain were modelled by means of the hybrid evolutionary algorithms HEA (e.g. Recknagel et al. 2014). Resulting inferential models reveal direct, indirect and cascading effects between the invasive species and the local zooplankton community. Results indicate that Zebra mussels: 1 directly affect Rotifers suggesting it preys on slow moving Rotifers, and 2 indirectly affect Cladocera and Copepods, and therefore Mysids by both, predation on Rotifers and grazing on phytoplankton. These findings may explain long-term patterns in zooplankton abundance and the decline of Mysids since the arrival of Zebra mussels in Lake Champlain.

41-O   Benthic community of Laurentian great lakes: spatial gradients and temporal changes.

Lyubov Burlakova

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North America's Laurentian Great Lakes comprise the largest lake system on earth, containing almost a fifth of the world's supply of surface freshwater. The US Environmental Protection Agency's Great Lakes National Program Office has been monitoring the Great Lakes since 1983, and in 1997 initiated a benthic invertebrate biomonitoring program to complement its existing offshore surveillance sampling. A unique aspect of this monitoring program is the extent of coverage, which includes annual sampling of 59 permanent stations across all five lakes, and the fact that a single agency

oversees the work, thus ensuring consistency in sampling and analytical methods. We used non-parametric multivariate analysis of data collected in 1997-2013 to provide a general description of the offshore benthic communities of all five Great Lakes, characterize large-scale spatial (10-1000 km) and temporal (15 years) distribution patterns of these communities, and to identify abiotic drivers of their species makeup and abundance. We found that the major drivers of the distribution, abundance, and species richness of benthic invertebrates were depth, chlorophyll a, and nutrients. Benthic species richness was the highest in shallowest and most productive Lake Erie, followed by Lake Ontario, Michigan and Huron; the lowest number of species was recorded in Lake Superior. Species assemblages changed significantly along the depth gradient with the highest density and diversity above 60-meters. We distinguish the major groups of benthic invertebrates along depths and trophic gradients, and describe changes in benthic community structure and dominance. These include a dramatic decline of *Diporeia* sp. in lakes Michigan, Huron and Ontario, and the invasion of exotic bivalves *Dreissena polymorpha* and *D. rostriformis bugensis*, which were among the most important potential drivers of changes in the benthic communities.

41-O   Bottom hypoxia is a major driver of *Dreissena* spp. distribution in Lake Erie.   *Alexander Karatayev* [1] - *Lyubov Burlakova* [1] - *Knut Mehler* [1] - *Serghei Bocaniov* [2] - *Paris Collingsworth* [3]

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Hypoxia or low bottom dissolved oxygen (DO) associated with cultural eutrophication and/or ongoing climate change recently became a major stressor both in freshwater and coastal marine ecosystems. In Lake Erie hypoxia seasonally occurs in the central basin of Lake Erie with possible intermittent hypoxic events of short duration in the western basin. Lake Erie was the first waterbody in North America that was colonized by both the zebra mussel (*Dreissena polymorpha,* first record in this lake in 1986) and the quagga mussel (*D. rostriformis bugensis*, first recorded in 1989). During the initial stage of colonization all three Lake Erie basins were widely populated by dreissenids with zebra mussels being the dominant species in most of the lake. However, by late 1990s quagga replaced zebra mussels in the central basin and especially in the deepest eastern basin with zebra mussels being still common in the shallow western basin. In 2014 we collected 322 samples from 112 sites using ponar grabs and SCUBA diving to estimate the density and distribution of dreissenids in Lake Erie. We then compared these data with the near-bottom DO concentrations for 2012 and 2013 predicted by the 3-dimensional (3D) previously calibrated and validated hydrodynamic-ecological model of Lake Erie. In this study, the 3D Lake Erie model results in the central basin were validated against monthly measurements of DO at ten index US EPA stations for 2012 and 2013, with additional validation against continuous observations of DO and temperature obtained from the 19 loggers deployed at different spatial locations with variable depths (14 to 24 m). Dreissenid densities were highest in the eastern basin and lowest in the central basin, where they were limited by hypoxia. Quagga mussels were found at all depths and in all basins, while zebra mussels were common only in the western basin where they still represent about 30% of the combined dreissenid density. In the western basin *Dreissena* spp. were much smaller than in the eastern basin. The near-bottom hypoxia was the most important environmental factor to govern the spatial distribution of dreissenids in the central basin of Lake Erie, resulting in almost complete elimination of mussels at depths over 20 m. Periodic hypoxia may also be an important factor limiting long-term survival of dreissenids in the western basin, reducing competition between dreissenid species, and allowing survival of zebra mussels for almost 30 years without being completely replaced with quagga mussels. We also found that monitoring of *Dreissena* occurrence and length-frequency distribution can be an effective tool in mapping the extent and frequency of hypoxia in freshwaters.

41-O   Examining the spatial and temporal dynamics of bottom hypoxia in Lake Erie using high resolution data.   *Paris Collingsworth* [1] - *Richard Kraus* [2] - *Glenn Warren* [3]

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Seasonal hypoxia is a regularly-occurring phenomenon in the bottom waters of many large lakes. In the Laurentian Great Lakes, seasonal hypoxia is relatively common in highly productive areas, such as shallow embayments, particularly

in the winter when ice and snow cover prevent photosynthesis. In Lake Erie, hypoxic conditions are common during the summer when stratification prevents adequate mixing in the hypolimnion. Summertime hypoxia in the central basin of Lake Erie is a well-documented and, likely, natural phenomenon.   However, there is increasing evidence that the duration and severity of hypoxic conditions are exacerbated, at least in part, by anthropogenic factors such as the loading of nutrients from tributaries. In order to fully account for such anthropogenic contributions, baseline estimates of the spatial extent and severity of hypoxia are required. Here, we present preliminary results from a monitoring program designed to provide a high-resolution estimate of the spatial extent of hypoxia in central Lake Erie. During the summers of 2014 and 2015, we deployed an array of 25 dissolved oxygen loggers throughout the central basin of Lake Erie, with an emphasis on near shore areas. The logger network is spread out over an area greater than 7000 km^2 and collects data at 10 minute intervals. Our initial results indicate that the hypoxic zone is dynamic, particularly along its edge and that rapid intrusions of hypoxic water into near shore areas are common. The development of hypoxic conditions follows a consistent spatial pattern, forming first in nearshore areas in the highly populated southwest shoreline of the lake and extending offshore and along the north eastern shoreline throughout the summer. We conclude our analyses with a comparison of our estimates of the size of the hypoxic zone to previously published estimates based on measurements taken from EPA historical data and discuss the implications of dynamic hypoxia for Lake Erie's food webs.

41-O   The off-shore shunt – the influence of top predators on nutrient and energy availability.

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Quantifying *in situ* nutrient and energy flows in spatially and temporally complex aquatic ecosystems represents a major ecological challenge. Food web structure, energy and nutrient budgets are difficult to measure, and it is becoming more important to quantify both energy and nutrient flow as food web processes and structure are modified by multiple stressors. We propose that polychlorinated biphenyl (PCB) congeners represent an ideal tracer to quantify *in situ* energy and nutrient flow between trophic levels. Here, we demonstrate how an understanding of PCB congener bioaccumulation dynamics provides multiple direct measurements of energy and nutrient flow in aquatic food webs. To demonstrate this novel approach, we quantified nitrogen (N), phosphorus (P) and caloric turnover rates for Lake Huron lake trout, and reveal how these processes are regulated by both growth rate and fish life history. Although minimal nutrient recycling was observed in young growing fish, slow growing, older lake trout (> 5 yr) recycled an average of 482 Tonnes·yr^{-1} of N, 45 Tonnes·yr^{-1} of P and assimilated 22 TJ yr^{-1} of energy. Compared to total P loading rates of 590 Tonnes·yr^{-1}, the recycling of primarily bioavailable nutrients by fish plays an important role regulating the nutrient states of oligotrophic lakes. We then further this concept using a non-steady state PCB bioaccumulation model to quantify nutrient and energy flows in both Pacific Salmon and Lake Trout under various warming scenarios to contrast the influence of life history traits and growth rates on nutrient and energy dynamics in Lake Huron and highlight how climate change might affect nutrient and energy availability within this system.

The results of this study demonstrate that Lake Trout are more effective at recycling nutrients and are critical for food web stability in these highly oligotrophic ecosystems, whereas Pacific salmon tend to act mostly as nutrient sinks. As fish reach their asymptotic length of the von Bertalanffy growth curve, the mass of nutrients they recycle increases. For Lake Trout, at approximately 5 years of age, their individual growth rates fall below 50% yr^{-1}, causing these upper age cohorts to become nutrient sources rather than sinks. Pacific Salmon, on the other hand, migrate to tributaries to spawn when individual growth rates decline below 50% yr^{-1} exporting significant masses of nutrients out of the lake. Given the differing life-spans, growth rates and reproductive strategies of Lake Trout relative to stocked Pacific salmonids in the Great Lakes, the results of this study demonstrate that Lake Trout provide a critical ecosystem service by effectively recycling nutrients to enhance food web stability in highly oligotrophic ecosystems.

41-O   Fish and fisheries impacts on large lake ecosystems.

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From the early 2000s, two rather similar concepts - Ecosystem-Based Fisheries Management (EBFM) and Ecosystem Approach to Fisheries (EAF) have attracted increasing attention that is reflected in expanding publication/citation records. EBFM is a new direction for fishery management, essentially reversing the order of management priorities to start with the ecosystem rather than the target species with the overall objective to sustain healthy ecosystems and the fisheries they support. EAF strives to balance societal objectives by taking account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries. Despite the distinctions between ecosystem management and fisheries management, the two concepts are in large extent overlapping. Most examples of EFBM and EAF are still coming from marine fisheries as long-term data from freshwater fisheries are rare. Moreover, even in most recent papers only fish communities are typically considered under the term of the 'ecosystem' and indirect or cascading fisheries impacts on other food web components remain largely or completely unstudied.

Fisheries are ecosystem-scale ecological experiments providing opportunities to test ecological theory through large-scale, repeated, and well-documented perturbations of natural systems. While freshwater fisheries undoubtedly provide valuable ecosystem services which have been the subjects of extensive scientific investigations, in some situations they may also result in sustained negative impacts on other components of the aquatic environment and thus on the ecosystem services that they provide. EBFM aims at better incorporation of ecological theory into decision making as fisheries management can be improved through better understanding of the ecology of exploited ecosystems. The so-called 'fishing down' of predators may have cascading top down effects and can even shift entire ecosystems into alternate stable states.

In the present study we analyse 4 large lake case studies (Võrtsjärv, Geneva, Maggiore and Windermere) with available long-term data on lake ecosystem properties and services, including fish and fisheries information. The aim of our analysis is to assess the extent and strength of top-down cascading effects of fish and fisheries at the whole ecosystem level in these case study lakes.

41-O   Algal biomass is proportional to phosphorus in nitrogen limited lakes.   *Piet Verburg* [1] - *Robert E Hecky* [2] - *Stephanie Guildford* [2]

Niwa, Hamilton, New Zealand [1] - University of Minnesota, Duluth, United States [2]

Algal biomass in lakes and rivers is often limited by nutrient concentrations especially at biomass maxima; and high nutrient concentrations can lead to undesirable levels of algal growth. Therefore, the reduction of nutrient loads in freshwaters is advocated to reduce algal abundance. The occurrence of waters with low nitrogen to phosphorus ratios, compared with freshwater in other OECD countries, has encouraged the promotion of nitrogen reduction as a tool to reduce algal biomass in New Zealand lakes. However, long term observations in several large lakes considered to be nitrogen deficient have shown that algal biomass is more responsive to phosphorus than to nitrogen loading. Some of the largest lakes in New Zealand that were considered to be nitrogen limited, based on bioassay results, have had their nitrogen and phosphorus concentrations modified by changes in nitrogen and phosphorus loading over recent decades. The effect of nitrogen on algal biomass was less than the effect of phosphorus in these lakes. 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.

41-O   Spatio-temporal dynamics of food webs in the ancient Lake Biwa: causes and consequences of changing biodiversity.   *Noboru Okuda* [1] - *Yoichiro Sakai* [2] - *Jun-ya Shibata* [3] - *Zin-ichi Karube* [4] - *Yoshikazu Kato* [5] - *Takefumi Komiya* [5] - *Yutaka Okuzaki* [6] - *Michio Hori* [5] - *Ichiro Tayasu* [1] - *Shigeo Yachi* [7] - *Shin-ichi Nakano* [7] - *Toshi Nagata* [8]

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In freshwater ecosystems, biodiversity loss has spread on the global scale with an accelerating rate since the last century, due to human disturbances, such as eutrophication, biological invasion and global warming. It is therefore a big challenge to identify anthropogenic drivers of the biodiversity loss and predict its ecosystem consequences. Although comparative approaches to analyze correlations between indices of biodiversity and human disturbances across a variety of lakes are often taken, they do not usually consider geographical variation in lake communities and the history of community colonization.

In order to understand causes and consequences of changing biodiversity in lakes under human disturbances, we focused on spatio-temporal dynamics of biodiversity and food webs in the ancient Lake Biwa, which is called a biodiversity hotspot with 1,769 aquatic species recorded, including 61 endemics. This lake has hundreds of tributary rivers, whose catchment areas greatly vary in the land use pattern and adjacent coastal areas are disturbed physico-chemically through lakeshore development works and river inflows. While conducting synoptic surveys, we examined how and which land uses alter coastal environments and consequently coastal communities, using a structural equation model (SEM) based on the DPSIR framework. The SEM revealed that the proportional area of paddy field in the catchment areas has a negative impact on coastal zoobenthos diversity through habitat degradation due to siltation. The stable isotope analysis (SIA) also demonstrated that the community average trophic level (TL) and benthivorous fish TL lower in less diverse zoobenthos communities.

Although it is also the common interest for limnologists to know causes and consequences of historical changes in the whole lake community, we have difficulty in doing so because its long-term data are usually limited or fragmented. Considering such a constraint, we reconstructed the past food web properties from isotope signatures of archival specimens, especially of fish specimens with three ecological niches (coastal benthivores, pelagic planktivores and top predators), collected from Lake Biwa during the last one century.

The SIA revealed that fish TLs did not show significant decadal changes during the first half of 20th century. In the 1970's when the lake shifted from oligotrophic to mesotrophic state, however, top predators increased their TLs, possibly due to increased availability and TLs of forage fishes. The predators, however, turned to decrease their TLs with the progress of eutrophication during the 1980's, in which coastal benthivorous fishes significantly decreased their TLs. In the 1990's, the spread of exotic predators and a climatic regime shift caused drastic decline in the abundance and TLs both for coastal and pelagic fishes, leading to substantial reduction in the native predators' TLs. However, the TLs of many fishes have recovered in the 21st century when some conservation programs were implemented in this lake.

In conclusion, large lakes provide good opportunities to identify anthropogenic drivers of the biodiversity loss, which can be indicated by food web alteration. The long-term variation in top predators' TLs, defined as food chain length, also suggest that biodiversity of the whole lake community have been changing under a variety of human disturbances.

41-O   Ecological model of the effects of an exceptional deep circulation in a pre-alpine lake.   *Giulia Valerio* [1] - *Marco Pilotti* [1] - *Steven Chapra* [2] - *Irene Caramatti* [1]

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The annual temperature cycle in deep temperate lakes is divided into periods of thermal stratification, that keep lower layers isolated from the surface, and periods of isothermal conditions with deep mixing. In these lakes the vertical extent of circulation is a decisive factor for the evolution of water quality and biocenosis, because dissolved substances, such as oxygen or nutrients, get distributed over the entire water body mostly through mixing events.

In the last decades, anthropogenic stress and climate change have intensified density stratification in lakes. In light of this behavior, several investigators argued that deep temperate lakes are likely to suffer in the future from reduced deep water mixing. The resulting expansion of anoxia would pose severe problems for deep-water quality.

From this point of view, Lake Iseo (a 256 m deep Italian lake) is an emblematic example. In 1967 the lake was a monomictic and oligotrophic lake, characterized by the oxygenation of the whole water column and phosphorous concentrations of few $\mu g \ l^{-1}$. Starting from the 1980s, trophic-induced processes have reinforced the persistence of chemical stratification triggered by meteoclimatic factors, inhibiting the lake's mixing and leading to a progressive deterioration of its water quality, related to the growing phosphorus concentrations and appearance of anoxic conditions of the water below 200 m. At the end of winter 2004–2005 and 2005-2006, convective mixing reached the bottom of the lake for the first time in 3 decades. However, the deep oxygenation was soon exhausted by the high sediment oxygen demand (SOD) of the bottom sediments, so highlighting the fundamental role that the sediments are going to play in the future evolution of this lake.

To better understand the ecological consequences of these exceptional deep-water renewals and their fast evolution, using LAKE2K we developed a 1D coupled hydrodynamic-ecological model for Lake Iseo. The model simulates the lake as a one-dimensional system consisting of three vertical layers and compute the vertical mixing between layers based on wind speed and water density. In addition to a complete heat balance, the ecological model includes the simulation of plant photosynthesis, plant respiration, nitrification, denitrification, sediment nutrient fluxes and sediment oxygen demand. Comparison of the model's results with the monthly measured profiles of oxygen, carbon, phosphorous and nitrogen compounds allowed us to corroborate the capability of the model in reproducing the ecological effects of the exceptional oxygen demand in the hypolimnion. The model calibration allows the investigation of the future effects of the nutrient reduction efforts under way in Lake Iseo as well as being useful to highlight some water quality issues that will possibly characterize other temperate deep lakes in a future climate change scenario.

41-O   Browning of a large Canadian lake (Lake Simcoe) and potential ecological consequences.

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Lake Simcoe is one of Canada's largest lakes located near its most populated and urban region (Toronto). Over the past three decades, the Lake Simcoe watershed has been subject to heavy urbanization, agricultural development, invasion by dreissenid mussels, in addition to warming temperatures brought about by climate change. These drivers have led to multiple ecological changes in the lake. One surprising biogeochemical finding in Lake Simcoe (not typically documented in large lakes) is a gradual increase in dissolved organic carbon concentration (DOC; browning) from an average of 4 mg L^{-1} in the 1980s to 5.2 mg L^{-1} in the past few years. To determine the nature and source of the DOC, tributary and lake waters were characterized using optical fluorescence. Initial results indicate that the DOC in Lake Simcoe is primarily allochthonous-like. Enhanced soil DOC decomposition rates driven by warming air temperatures and subsequent inputs of mineralized DOC into Lake Simcoe are possible causes of this DOC increase. Some ecological responses may be linked to the rise in DOC. Concomitant with the increase in DOC is a related decline in dissolved inorganic carbon (DIC), stabilization of secchi disk depths, and potential zooplankton community changes.

41-O   Ecological change in Lake Hovsgol, Mongolia's largest lake.

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Lake Hovsgol, Mongolia's largest freshwater lake and the 19th largest lake in the world by volume, is among the world's most pristine and unique lakes. Despite its remoteness, protected status, and low human population density, Lake Hovsgol is threatened by the synergistic pressures of climate change, water pollution, overfishing, and development. Analysis of local weather station data reveals a 1.8°C increase in air temperature over the last half century, a rate of warming more than three times the global average, which contributes to the drying of many previously reliable streams

and the loss of fish spawning habitat. Surveys for pelagic microplastics and shoreline macroplastics indicate that Lake Hovsgol is more polluted than other more developed and densely populated watersheds owing to its lack of waste management system and long residence time. Interviews with herders and park rangers and shoreline surveys for derelict fishing gear suggest that gillnet fishing, though illegal, is an important source of food and income for the resident herder population and that fishing effort is increasing in intensity. Although stable isotope analyses suggest that food web structure has not changed over the past decade, analyses of long-term monitoring data suggest that fish populations, particularly Hovsgol grayling (*Thymallus nigrescens*), burbot (*Lota lota*), and roach (*Rutilus rutilus*), are in decline. It is difficult to know whether these declines are due to overfishing or climate change without robust measurements of fisheries removals, but data-poor stock assessment analyses indicate that plausible levels of fishing have the capacity to overexploit the endangered, endemic Hovsgol grayling population. These issues are likely to be exacerbated as access and tourism increase and the way in which these issues are resolved or ignored in the iconic Lake Hovsgol National Park could shape future protected area management in Mongolia.

41-O   Nearshore assessment of Lake Ontario south shore using emerging technologies.   *James Watkins [1], Glenn Warren [2], Kristen Holeck [3], Lars Rudstam [4]*

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The nearshore habitat of the south shore of Lake Ontario was evaluated using a Triaxus towed underwater vehicle from July 15-18, 2013 as part of the 2013 Lake Ontario Cooperative Science and Monitoring Initiative (CSMI) efforts of the US Environmental Protection Agency (US EPA) Great Lake Program Office (GLNPO). Deployed sensors (CTD, Fluoroprobe, Phytoflash, and Laser Optical Plankton Counter (LOPC)) tracked water quality, phytoplankton, and zooplankton distributions on a west to east path along the coast at the 20-meter contour from Burlington, Ontario to Chaumont Bay, New York. This path (undulating from near surface to 15 meters depth) crossed plumes entering the lake from Hamilton Harbor, the Niagara River, and the Genesee River at Rochester, New York. Water chemistry and biological distributions are compared to station based nearshore monitoring conducted within the multiagency Lake Ontario US Biomonitoring Program. 2013 data is also compared to a similar towed package effort conducted in the last intensive survey of 2008 (Yurista et al. 2012).

41-P   Effect of sediment resuspension on interactions between visually-oriented and filter-feeding fishes and zooplankton in a shallow lake using enclosure experiments.   *Feizhou Chen, Libin Zhou*

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Sediment resuspension (SR) can impact ecosystems through direct and indirect effects on freshwater organisms and their interactions. This study was conducted to compare the effect of SR on interactions between visually-oriented (*Hemiculter leucisculus*) and filter-feeding (*Aristichthys nobilis*) fishes and zooplankton in a shallow lake using two enclosure experiments with sediments from Lake Taihu, a large shallow lake in China. SR was divided into three intensities: strong, weak and no SR. In the experiment with *H. leucisculus*, no significant difference in zooplankton abundance was observed between fish and no fish treatments under strong and weak SRs, whereas there was a significant difference under the no SR treatment. In the experiment with *A. nobilis*, zooplankton abundance was significantly higher in the no fish treatment than in the fish treatment under all three SR conditions. The results indicate that SR had a greater inhibitory effect on zooplankton predation by visually-oriented fish but a lesser effect on zooplankton predation by filter-feeding fish, which suggests that zooplankton communities in shallow lakes can be affected by the composition of fish communities under different SR conditions.

41-P   Monitoring and assessment of large lakes: within- and between-lakes variation in assemblages of littoral invertebrates.   *Ann Kristin Schartau [1] - Bjørn Walseng [1] - Knut Andreas Bækkelie Eikland [2] - Terje Bongard [2]*

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Norway has many of the largest and the deepest lakes of Europe. The implementation of the EU's Water Framework Directive in Norway require establishment of a surveillance monitoring program for these lakes including both water chemistry and biological quality elements (phytoplankton, water plants, invertebrates and fish). The purpose of this monitoring is to assess the ecological status and to follow trends related to environmental stress and climate changes. A hole-lake assessment require samples from a representative selection of monitoring sites, taking geographical variation within the lake into consideration. Generally, we have little knowledge of natural- and anthropogenic-induced variation of the biological communities of shallow waters and which factors that affect this variation. In this project, we have studied within and between-lakes variation in assemblages of littoral macroinvertebrates from seven lakes representing different lake types and environmental conditions. In addition, samples on littoral microcrustaceans were included from two of these lakes. Depending on lake size, we took samples from eight or ten sites, respectively two (macroinvertebrates) and three times during the growing season (microcrustaceans). At each site, we sampled macroinvertebrates from stony substrates only, whereas we sampled microcrustaceans from both stony substrates and vegetation. For each lake and substrate-type, we established rare-fraction curves as function of the number of individuals sampled and the number of samples taken. The correlation between respectively macroinvertebrates and microcrustaceans, and environmental data were tested using simple and multiple regressions (species richness and other biotic indices) and single- and multivariate statistical methods (species communities).

41-P   Environmental factors promote quagga mussel (*Dreissena bugensis*) spreading in Lake Balaton.
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Balaton Limnological Institute, Hungarian Academy of Sciences Centre for Ecological Research, Tihany, Hungary

Dreissenids are invasive bivalves exerting high pressure on freshwater ecosystems.
Datasets collected from the early invasion of quagga mussel in Lake Balaton (2008-2015) enable to reveal those environmental factors that influence the successful colonization and spreading of this mussel in the largest shallow lake of Central Europe.y 2009, as early as one year after its first detection, quagga mussel (D. bugensis) population had established in the lake and occupied habitats as a new competitor of zebra mussel (D. polymorpha) which density now are much reduced due to the quagga mussel over-domination. Therefore, Lake Balaton gives a rare and unique precedent for following and examining the mutual interaction between the two species and its consequence on the ecology of the lake.
Lake Balaton underwent eutrophication in the 1970-1995 period, then, from that time up to now, thanks to a fruitful scientist – politician collaborative action – to diminish contamination load in the catchment area, the water quality improved and the phytoplankton biomass decreased considerably. This leaded to the current situation wherein a trophic gradient from meso-eutrophic Western to oligotrophic Eastern basins can be recorded. Along this axis we found marked difference between the density patterns of the two Dreissenids suggesting that the primary deterministic factor of their distribution is the trophity. Secondly, the depth rate of colonization surfaces and other minor but possibly important factors being detailed in the talk also significantly influences the spreading of quagga mussel and the charasteistic of co-existence of the two Dreissenids.

42. ALPINE AND POLAR PALAEORECORDS OF NATURAL AND ANTHROPOGENIC ENVIRONMENTAL CHANGE

42-O   Climate change drives new thermal and ecological regimes in tropical Andean lakes.   *Neal Michelutti, Andrew Labaj, Christopher Grooms, John Smol*

Department Of Biology, Queen's University, Kingston, Canada

Warming in the Andes has already affected phenology, glaciology, and other ecosystem changes, and now threatens to alter long-standing fundamental limnological properties. Equatorial mountain lakes have been a scientific curiosity for decades, mainly because of their unique limnological characteristics, imparted by their tropical, high-altitude location. In the equatorial Andes, most lakes have traditionally been characterized by waters that circulate continuously, with only rare episodes of stratification. This categorization, albeit based on relatively few studies, has scarcely been challenged in light of accelerated regional warming that has occurred over the past 30 years. Recent paleolimnological studies from the Andes of Ecuador and Peru have documented abrupt changes in planktonic algal assemblage beginning within the last 50 years, which suggests the lakes have possibly entered new physical states of extended periods of thermal stratification. The timing of these changes coincides with regional records of rising air temperatures and declining wind speeds, which are two key variables that could affect thermal stratification. Despite the paleolimnological evidence suggesting new limnological regimes for these lakes, the following questions still remained: Do these lakes stratify thermally? And if so, what is the duration and degree of stratification? Here, we show that protracted periods of thermal stratification are presently the norm, not the exception, in equatorial mountain lakes. Annual circulation and stratification patterns recorded in four lakes from Ecuador's southern Sierra show extended periods of stratification, which are stable and do not break down with nocturnal cooling. These data contrast earlier research from this region, which reported full water column mixing and only infrequent stratification, but are consistent with recent trends of rising temperatures and declining wind velocities. Paleolimnological studies show that changes to the thermal regimes of these lakes likely began several decades ago and have resulted in ecosystem-scale changes including regime shifts in phytoplankton and declines in aquatic production.

42-O   Climate imprints and forcing mechanisms in the iberian central range during the last two millennia. *Guiomar Sánchez-López [1] - Armand Hernández [2] - Sergi Pla-Rabes [3] - Manuel Toro [4] - Ignacio Granados [5] - Pere Masqué [6] - María Jesús Rubio-Inglés [1] - Alberto Sáez [7] - Santiago Giralt [1]*

Institute of Earth Sciences Jaume Almera (ICTJA), Spanish National Research Council (CSIC), Barcelona, Spain [1] - Instituto Dom Luiz (IDL), Universidade De Lisboa, Lisboa, Portugal [2] - Centre De Recerca Ecològica I Aplications Forestals (CREAF), Spanish National Research Council (CSIC), Barcelona, Spain [3] - Centro De Estudios Hidrográficos (CEDEX), Spanish Ministry of Agriculture, Livestock And Environment, Madrid, Spain [4] - Centro De Investigación, Seguimiento Y Evaluación, Parque Nacional De La Sierra De Guadarrama, Madrid, Spain [5] - Departament de Física and Institut de Ciència I Tecnologia Ambientals, Universitat Autònoma de Barcelona, Barcelona, Spain [6] - Faculty of Geology, Universitat de Barcelona, Barcelona, Spain [7]

The multi-proxy reconstruction from sediments of an Iberian alpine lake (Cimera, 2140 m asl) have allowed to establish the climatic conditions in the Iberian Central Range (ICR) over the last two millennia. The comparison with other Iberian reconstructions permitted to identify possible forcing climate mechanisms.
Geochemical and mineralogical datasets revealed that climatic conditions would be transmitted to the sediments via the frequency of extraordinary run-off episodes, derived from rain-on-snow events, and the lake productivity, ruled by ice-cover duration.

The early Roman Period (RP; 200 BC – 350 AD) in the ICR was characterized by short-lived oscillations of extraordinary run-off conditions, likely as a consequence of an alternation between cold and warm periods. From the second half of the RP to the onset of the Early Middle Ages (EMA; 350 – 500 AD) an increase in the extraordinary run-off events suggests a predominance of warm conditions, although a noticeable decrease during the rest of the EMA (500 – 900 AD) evidences a shift to very cold temperatures in this region. In terms of humidity, both the RP and the EMA climatic periods displayed a transition from a dry to a wet scenario that led to a decrease in lake productivity. These climatic conditions have been partly registered by other reconstructions in the Iberian Peninsula (IP), and a North-South humidity gradient could be envisaged, although spatial climatic discrepancies were significant. Precipitation and temperature in the IP present a more homogeneous spatial pattern when the North Atlantic Oscillation (NAO) and East Atlantic (EA) modes have the same sign than when they have the opposite sign. Hence, a predominance of periods with NAO – EA in opposite phases could explain the climatic spatial heterogeneity in the IP during these two periods.

The Medieval Climate Anomaly (MCA; 900 – 1300 AD) in the ICR was characterized by warm and dry conditions represented by an increase in exceptional run-off episodes and lake productivity whereas the Little Ice Age (LIA; 1300 – 1850 AD) showed the opposite scenario. Similar climatic conditions were registered in all the IP, reflecting a spatial climatic homogeneity. The climatic conditions attributed to the MCA and the LIA are consistent with a change from a predominant positive phase of the NAO during the MCA to a prevalence negative NAO phase during the LIA. Additionally, a predominance in the coincidence of NAO – EA phases (both modes positive during the MCA and both negative during the LIA) could reinforce this spatial homogeneity.

42-O   Understanding lake temporal and spatial patterns of siliceous algae enrich the interpretation of paleolimnological records. *Sergi Pla-Rabés, Jordi Catalan*

Creaf, Uab, Cerdanyola del Valles, Spain

Siliceous algae (Bacillariophyceae and Chrysophyceae) are an important component of communities from freshwater ecosystems that have been extensively used in paleolimnology to reconstruct past environments. However, sediment samples are a composite taphonomic assemblage of diatom frustules and chrysophyte cysts from different lake habitats. Chrysophytes are mainly planktonic and show a seasonal replacement throughout the growing season. Understanding this temporal partitioning allows the interpretation of sediment records regarding seasonal variability. Diatoms can be both planktonic and benthonic. Lake ecosystems show a diversity of benthic habitats characterized by the variation in the substrate, light and nutrients, and seasonal stability. This spatial differentiation and the environmental differences associated with them are apparently lost in the taphonomic assemblage of the sediment record. However, understanding the precise relationship between species and habitat can significantly enrich the interpretation of paleolimnological records.

42-O   How synchronous are changes in three high alpine lakes over the holocene?   *Karin Koinig* [1] - *Elena Ilyashuk* [1] - *Boris Ilyashuk* [1] - *Sergi Pla* [2] - *Roland Psenner* [3]

Institute of Ecology, University of Innsbruck, Innsbruck, Austria [1] *- CREAF, UAB, Cerdanyola Del Valles, Spain* [2] *- Institute of Ecology, University of Innsbruck and EURAC Bozen, Innsbruck, Austria* [3]

High alpine lakes are among the ecosystems reacting particularly fast and sensitive to climate change. Their sediment records are therefore frequently used for inferring climate change. However, not all records allow for a temperature reconstruction especially when they are located very high, and thus at or beyond the limit of established temperature data sets. Still major shifts in the multi proxy records can be used to observe the timing and synchrony of climate impacts. Here we compare the timing and the type of reaction in three high alpine lakes located between 2680 and 2960 m a.s.l., i.e. far above timberline on the southern and northern slope of the Eastern Alps. We apply a multi-proxy approach of radio carbon dated sediment records, including diatoms, chironomids, nutrients and geochemical indicators. The sediment records all go back to the formation of these high alpine lakes over 10000 years ago. Direct human impact is absent in these lakes or limited to grazing by sheep in the catchment over the last decades. This allows for a reconstruction of natural, mainly climate driven changes over the Holocene. These lakes respond directly to climate warming, the amount of winter precipitation, and snow events in late spring which are strongly affecting the ice cover duration and, in consequence, the biology and limnochemistry of these lakes. Yet, are the changes following major climate shifts, like the 8.2 kyr cold event, the Roman warm period or the little ice age similarly and synchronously

affecting both the different proxies within a lake and the records of different lakes? While major climate shifts, like the 8.2 kyr event or the Roman warm period, leave their traces in at least one proxy record of each lake, the reaction to more gradual events is more divers. Asynchronous changes point to divergent changes in the catchment, like the acid melt water input from a rock glacier to one of the lakes.

42-O   Temperature-driven increase in organic carbon burial in a subarctic lake.   *Marttiina Rantala* [1] *- Tomi Luoto* [1] *- Liisa Nevalainen* [2]

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Recent widespread increases in the concentrations of organic carbon in lakes across the Northern Hemisphere have raised concerns about the role of the ongoing climate warming on aquatic carbon balance. No scientific consensus exists on the underlying cause for the pattern. Long-term paleoenvironmental records from remote lakes in the circumpolar arctic allow us to examine the magnitude and mechanism of change in aquatic organic carbon pools prior to and under anthropogenic influence, as well as to assess their impact on lake ecosystem functioning.

We examined the elemental and stable isotopic composition of sediment organic matter in connection with Chironomidae-inferred summer air temperature in a shallow treeline lake in northern Finland (70°N), to track climate-driven changes in the terrestrial export of organic carbon during the Little Ice Age (LIA) and the recent warming. Additionally, we investigated concomitant effects on the carbon utilization of zooplankton from the stable isotopic composition of cladoceran (Chydoridae) exoskeletons. Comparable biogeochemical data from 31 shallow lakes in the region were used to refine the interpretations.

The Chironomidae-based temperature reconstruction depicted the cool climate interval between ca. 1300 and 1900 C.E., with the coldest period between 1700 and 1850 C.E., as well as the recent warming. The geochemical data indicated that the sediment organic carbon in the lake originates largely from benthic autotrophic production, yet the stable carbon isotopic composition of organic matter ($\delta^{13}C_{OM}$) and the elemental ratio between carbon and nitrogen (C/N ratio) tracked changes in terrestrial carbon inputs. The stable isotopic composition of zooplankton ($\delta^{13}C_{ZOO}$, $\delta^{15}N_{ZOO}$) similarly responded to changes in the sources of organic carbon, although overall variation was small. The organic carbon content of the sediment was stable during the LIA but showed a distinct increase coincident with the 20th century warming. The shift was attributed both to increased export of terrestrial organic carbon as well as enhanced aquatic production. Overall, our record suggests a tight connection between the global warming and organic carbon sequestration by lakes.

42-O   6000 year of lake internal dynamics as reflected by multi-proxy analysis of Lake Ighiel sedimentary record (Carpathian Mts., Romania): the role of natural and anthropogenic driving factors.   *Aritina Haliuc* [1] *- Daniel Veres* [1] *- Katalin Hubay* [2] *- Mihaly Braun* [2] *- Robert Begy* [1] *- Achim Brauer* [3] *- Simon M. Hutchinson* [4]

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Climate change and its effects on environment and human society including political, economic and societal affairs are now challenging the scientific community to produce reliable models in predicting near and long-term future climatic behaviour. In order to address this issue and gain better understanding of how climate system works and which are the processes behind climatic variability, we rely on indirect information from natural archives. The high-resolution, proxy information stored in lacustrine sediments for example has been shown to allow deciphering past climate and environmental variability and assist in such predictions.

In the present study, we employ radiometric-dating methods (^{210}Pb, ^{14}C), μ-XRF measurements, long-core sedimentary logging, environmental magnetic proxies (susceptibility, natural and induced remanences) in an attempt to trace the evolution of Ighiel lake-catchment system during past 6000 years. Based on proxy behaviour, the sedimentary record was divided in six lithological units, each representing the unique sedimentation mode in response to internal and

external changes affecting the depositional environment. The first phase in lake evolution covers the Middle and Late Holocene and is dominated by high deposition rates and low lacustrine productivity portraying a dynamic system at the inception of lake-catchment system. The stabilisation of the newly formed system takes place between 4000 and 3500 cal yr B.P. when the sediment supply decreases, oxic conditions prevail and biological productivity increases. Between 3500 and 100 cal yr BP the depositional environment is dominated by alternating stable and unstable conditions, likely reflecting intense modulation by human activities. The behaviour of the proxies employed portray the last 300 years as being the most unstable phase in lake's evolution. The main catchment erosional events identified in most of the parameters around 5200; 4800; 5400; 5250; 4500; 4050; 3800; 3500; 3250; 3050; 2650; 2350; 2250; 1400; 1100; 500; 100 cal yr BP appear synchronous with regional hydro-climatic indexes such as precipitation and total solar radiation pointing to a casual link between lake dynamics and natural climate variability. Although, difficult to disentangle, the changes observed in lake evolution reflect also contribution of anthropogenic factors, starting with the Bronze Age and extending towards recent times, with a particular impact during the Late Antiquity and the Medieval Period.

42-P   Development of the lake ecosystem, palaeoclimate and palaeoenvironment on the Kola Peninsula (NW Russia) as reconstructed from sediment record of the Lake Antyukh-Lambina.

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Arctic regions are highly sensitive to changes in temperature and precipitation, and their Late Quaternary environmental history is very important for understanding of present and past climate trends. In spite of a generally increased attention to the palaeoclimate of Fennoscandia over the last decades, palaeoclimatic data from the Kola Peninsula are still fragmentary. The Kola Peninsula lies almost entirely above the Arctic Circle. The climate of the Peninsula is under the influence of North Atlantic and Arctic air circulation. The typical features of the regional climate are cool and rainy summers, relatively mild winters, and unstable and suddenly changing weather caused by frequent changes in air masses related to frontal passages (Elshin and Kupriyanov, 1970).
We studied Lake Antyukh-Lambina which is the shallow bay of the Kolvitsa Lake (N 67.07; E 33.31). We investigated three meter sequence of the bottom sediments by lithological, micropalaeontological (in particular chironomid). The core was dated using radiocarbon analyses. Mean July air T was reconstructed using North-Russian chironomid-based inference model (Nazarova et al., 2015). Analyses of lithological sequences and radiocarbon dating of sediments present a clear outline of the development of the lake ecosystem and studied region from 13000 cal. years BP to the present day.
Cluster analysis identified four main stratigraphic zones. There was a shift in taxonomic composition of chironomids during the lake development: 1. (13000 – 11000 cal. years BP) Lowermost zone is marked by dominance of chironomid taxa associated with macrophytes. In the upper part of the zone *Chironomus plumosus*-type is dominant, a taxon that is tolerant to low oxygen concentrations and sometimes to acidification. We assume that during this initial stage of the lake formation the lake was surrounded by wetlands, and the lake water was eutrophic. 2. (11000 – 8700 cal. years BP) The chironomid communities include many taxa associated with aquatic vegetation, and the taxa indicators of the moderate or cool temperature conditions. Species composition of chironomid communities indicates some cooling. 3. (8700 – 4400 cal. years BP) The dominant taxon *Sergentia coracina*-type (cold-water and acidophilic) is decreasing in the upper part of the zone, and *Heterotrissocladius marcidus*-type, and then *Heterotrissocladius maeaeri*-type 1 become dominant. Across the zone *Microtendipes pedellus*-type (medium temperature) is frequently met. Reconstructed air temperatures are higher than in the previous zone. 4. (4400 cal. years BP to present) Cold-water taxa dominate. Reconstructed conditions are close to modern.

42-P   Functionality and carbon utilization of benthic food webs in subarctic lakes – a paleolimnological approach.

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Small and shallow high latitude lakes are dynamic systems with strong environmental controls and sensitive ecological balance. These systems are usually dominated by benthic production due to their shallowness and high water transparency. The current climate change is expected to alter the amount of catchment derived allochthonous carbon transport into such lakes, which may have a significant effect on benthic food web structure and functioning. The main aim of this study is to investigate the relationships between chironomid (Diptera: Chironomidae) functional groups (feeding guilds) and functional diversity, isotopic composition of their fossil head capsules and limnological and geochemical attributes across a gradient of aquatic carbon and nutrient composition. This is done in order to better understand the functional responses of benthic food webs to limnological, catchment and further climatic attributes under the context of environmental change.

Our data set comprises surface sediments and limnological parameters of 25 subarctic lakes from Northern Finnish Lapland. The study area extends over a 125 km South–North transect and includes a wide gradient of both limnological and catchment variability with a vegetation change across the tree line from boreal coniferous forest to treeless tundra. The water was measured for primary production (Chlorophyll a concentration), main nutrients (total nitrogen (TN) and phosphorus (TP)) and organic carbon variables (dissolved organic carbon, colored dissolved organic matter, specific UV absorbance). Sediment analyses feature elemental (% of nitrogen (%N), and carbon (%C), carbon to nitrogen ratio (C/N)) and isotopic ($\delta^{15}N_{OM}$, $\delta^{13}C_{OM}$) composition, and amount (loss-on-ignition (LOI)) of organic matter. In addition, chironomid feeding guilds (collector-gatherer (c-g), collector-filterer (c-f), shredder (shr), predator (prd)) and functional feeding diversity were assigned based on their sedimentary community structure, and the isotopic signatures ($\delta^{15}N_{CHI}$, $\delta^{13}C_{CHI}$) of the fossil chironomid head capsules were determined.

Both the chironomid isotopic values ($\delta^{13}C_{CHI}$ = -20 – -34‰, $\delta^{15}N_{CHI}$ = 0.3 – 4.6 ‰) and feeding guild structure showed considerable variation within the dataset, with c-g being the most common feeding guild. Sedimentary and chironomid isotopic values correlate highly (Pearson R >0.9, p <0.001), emphasizing the importance of detritus as a major nutrition source for chironomids. Preliminary multivariate analysis indicates linkages between the isotopic and limnogical variables, TN is a major variable affecting $\delta^{15}N_{CHI}$, and $\delta^{13}C_{CHI}$ is connected with the C/N of the bulk organic matter, indicating connection to allo-/autochthonous carbon dynamics. Also the functional feeding diversity is linked to the $\delta^{13}C_{CHI}$. The results are promising for disentangling carbon related food web dynamics and offer possibilities for future down core applications.

43. ECOSYSTEM MEANAGEMENT IN AQUATIC ENVIRONMENTS WITH SUSTAINABLE HARVESTING AND EFFECTIVE UTILIZATION OF OVERGROWING MACROPHYTES.

43-O   Novel lake ecosystem management by sustainable harvesting and effective utilization of aquatic macrophytes biomass; overview for the concept of our on-going project.   *Syuhei Ban [1] - Tatsuki Toda [2] - Kanako Ishikawa [3] - Akio Imai [4]*

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There are a lot of problems related to overgrowing aquatic macrophytes in many lakes and rivers throughout the world. The costs for harvesting are increasing year to year, e.g. 50-100 million Japanese yens (400-700 thousand euros) a year in Lake Biwa. Historically, aquatic macrophytes were harvested for fertilization in agriculture in Japan. But they are no longer used now, because chemical fertilizers are better in growth, easier and cheaper in use than the macrophytes are done as a fertilizer. To develop effective utilization of aquatic macrophytes is therefore the most important for resolving this issue. On the other hand, sustainably harvesting the macrophytes is also important for management in aquatic ecosystems, because the macrophytes play a key role in an aquatic ecosystem as nursery ground and refuges for other small organisms living in littoral area. The aims of our on-going project are, therefore, to make an index for managing the macrophyte abundance to keep healthy and sustainable lake ecosystem and to develop fundamental technology for effective use of the macrophyte biomass harvested. We conducted four working packages; 1) to evaluate biomass and production of macrophytes in whole lake area in order to clarify the amount of macrophytes harvested every year for its sustainable utilization and keeping healthy lake ecosystem, 2) to evaluate the effects of harvesting macrophytes on water quality and bottom sediment in the lake, 3) to develop effective treatment technology of the macrophyte biomass with a methane fermentation, and 4) to develop mass culture technique for micro-algae, e.g. *Chlorella* sp. to eliminate major nutrients from the effluents from the methane fermentation. The energy from methane fermentation of the macrophytes will be able to return to human society as heat or electricity, and micro-algae as highly functional food supplement for aquaculture and livestock production. This modern recycling system using novel techniques, methane fermentation and micro-algal culture, will be helpful for conservation of lake ecosystem through sustainable utilization of aquatic macrophytes.

43-O   Sustainable harvesting of submerged macrophytes in consideration of the ecosystem and biodiversity.   *Kanako Ishikawa [1] - Hiroki Haga [2] - Eiso Inoue [1] - Syuhei Ban [3]*

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The growth of submerged macrophytes expanded rapidly after 1994, especially in the South Basin of Lake Biwa, and since that time long-term chlorophyll a concentration has been decreasing, suggesting a so-called "ecological regime shift" is occurring. Since 2002, their overgrowth has caused harmful impacts such as oxygen depletion at the lake bottom and/or lentic algal blooms, as well as having detrimental effects on fisheries, navigation, and the scenic value of the lake. The local government has been cutting and removing macrophytes to reduce the damage and to conserve the lake ecosystem.

In this study, we investigated the biomass of macrophytes in the South Basin and calculated the biomass for the purpose of recycling. According to long-term records the maximum biomass in a year has varied between 500-18,000 dry-tons (8.6-310 dry tons km^{-2}) since 1936 and between 3,000-18,000 dry-tons (54-310 dry-tons m^{-2}) over the last 20 years. The macrophytes grow by approximately 2,000 dry-tons per month (34 dry-tons km^{-2} per month) from May to September. The local government harvested 500 dry-tons per year

from 2011-2014, which is only 3-15% of the total biomass. However we do not know how much volume is appropriate for sustainable harvesting. It is important to take care of the overall ecosystem balance as well as to control macrophytes.

Therefore, we observed benthic animals and periphyton while controlling macrophytes volume. We will suggest a benchmark macrophyte biomass amenable to scientific analysis taking into consideration the ecosystem and biodiversity. This study will provide a basic idea of the guidelines for macrophyte management in lakes.

43-O   Does increasing harvesting frequency increase total harvest? a study on *Myriophyllum spicatum*.

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Many shallow freshwater ecosystems are influenced by human activities. Eutrophication is one of the major processes affecting the functioning and community structure of these ecosystems. In ecosystems where submerged aquatic plants are still able to grow, massive growth of one or a few species has occurred in many parts of the world leading to a variety of problems. However, submerged aquatic plants in general are beneficial for the stability and biodiversity of a clear water ecosystem, and have therefore also been used restoration projects. Rooted submerged aquatic plants are able to take up nutrients from both the water and sediment. Once the nutrients are captured by the plants, they can be recovered by harvesting the plants and repurposed as a fertilizer for example, partially closing the nutrient cycle. Furthermore, mowing a plant community where one species dominates, reduces nuisance caused by this species and might also give other species (including charophytes) a chance to grow and thereby increase plant diversity. However, mowing should not be too intensive as the vegetation could then be impacted to the point of collapse. But what the ideal mowing intensity is with respect to nutrient recovery, while maintaining the submerged vegetation is still largely unknown.

In this study we tested what the effect of mowing intensity (i.e. frequency) was on the amount of biomass, nitrogen and phosphorus harvested on a *Myriophyllum spicatum* dominated submerged vegetation.

We performed four plant harvesting treatments (mowing 1, 2, 3 or 5 times from May to September) in large outdoor shallow ponds and found that intermediate harvesting frequencies removed most biomass and nutrients. The dominance of *M. spicatum* in the vegetation was best maintained in plots mown only once or twice, while charophytes became more pronounced in plots that were mown more frequent. Finally we briefly explored the possible consequences of nutrient availability for the plants on the measured vegetation parameters.

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43-O   Comparison in nutrient and mineral elution between sediment covered with and without macrophyte litter in Lake Biwa, Japan.

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Understanding the appropriate way and degree of macrophyte harvesting would be important for sustainable macrophyte utilization in the lacustrine environment. Effects of macrophyte harvesting on the aquatic environments can be classified into two groups, that is acute and chronic ones. Mechanical disturbance of surface sediment by the harvesting tools such as digging out of macrophyte roots can be direct and acute effects of harvesting processes. Meanwhile, decrease in the amount of macrophyte litter on the lake bottom should cause another concern that probably persist for a relatively long period. In the presence of the macrophyte litter the water flow adjacent to the bottom is physically decreased and the sediment oxygen demand is biochemically increased by microbial activity on the litter. These effects expand the anoxic conditions even in the surface sediment underneath the macrophyte litter. In this regards, it can be said that macrophyte harvesting likely enhances the spread of oxic conditions in the surface sediment and thus changes the nutrient and mineral elution from the sediment.

  To examine the appropriate way and degree of macrophyte harvesting, we first qualitatively estimated the difference in nutrient and mineral elution from sediment covered with and without macrophyte litter. Effects of the presence of macrophyte litter on the elution from sediment were examined by 1) the indirect flux analysis based on the vertical concentration gradient in the surface sediment within the sampled sediment cores, 2) the direct flux calculation based

on the anoxic incubation of the small sediment cores, 3) the direct and indirect flux calculation based on the porewater and bottom water quality before and after the addition of macrophyte litter. As the results, we succeeded in understanding the effects of macrophyte litter that were positive in elution for some of the nutrient and mineral ion and negative for some of the other ions. However, the mechanisms causing these differences still remained unclear. Porewater conditions related to the nutrient and mineral elutions from sediment were discussed by considering the carbon and nitrogen metabolisms in addition to pH and ORP (oxidation/reduction potential) in surface sediment. Finally, we are to ascertain whether the decrease in the amount of macrophyte litter was good for the surface water environment or not.

43-O   Biogasification potential of harvested submerged macrophytes.   *Tatsuki Toda[1], Mitsuhiko Koyama [2], Masaaki Fujiwara [1], Shinichi Akizuki[1], Shuichi Yamamoto[1], Kanako Ishikawa[3], Syuhei Ban[4]*

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Overgrowing macrophytes have been causing various environmental issues throughout the world. The treatments of harvested macrophyte is one of the largest concern, but the effective and low-cost treatment have not been established yet, due to the high moisture and mud contents. Anaerobic digestion (AD) is effective technology for bioenergy recovery from wet and muddy biomass with low operational cost. In recent years, lignocellulosic biomass has been given its attention as prospective feedstocks for AD treatment. However, the chemical composition in relation to the CH_4 recovery of submerged macrophytes has scarcely been investigated yet. Submerged macrophytes have more flexible and softer body structure in order to adapt to the water flow, as compared with terrestrial herbaceous plants. Thus submerged macrophytes may have different digestibility with other types of plants. The present study investigated the biomethane production potential of harvested submerged macrophytes.

First, biomethane potential (BMP) of five dominant submerged macrophyte species in relation to the chemical composition was investigated in mesophilic (37ºC) temperature. The lignin content of the submerged macrophyte widely ranged depending on species from 3 to 21%-total solid. The total methane yield of submerged macrophytes greatly varied from 161 to 361 mL g-VS^{-1} depending on species (*Elodea nuttallii > Egeria densa > Potamogeton malaianus > Ceratophylum demersum > Potamogeton maackianus*). Macrophytes except *P. maackianus* was labile, indicating some submerged macrophytes are feasible for AD treatment. For the lignin-rich macrophyte (i.e. *P. maackianus*), delignification pre-treatments is required for AD treatment. The present study revealed that the CH_4 recovery of submerged macrophytes was regulated by the lignin content, as well as other lignocellulosic biomass.

Next, seasonal variation of BMP of submerged macrophytes in relation to the chemical composition were investigated, in order to estimate the year-round CH_4 recovery potential from harvested macrophyte. *El. nuttallii*, *Eg. densa* and *P. maackianus* were harvested monthly during the harvesting season (June to October). The CH_4 recovery of macrophytes significantly fluctuated with both species and the harvested month. The coefficient of variation (CV) of CH_4 yield with different species was 22-32%, while the CV of CH_4 yield with different harvested month was 7-13%. These results indicate that the harvested month has little effect on digestibility of submerged macrophytes. Consequently, it was suggested that the annual CH_4 recovery potential of submerged macrophytes can be estimated mostly by the species composition and the harvested yield

43-O   Effective nutrient removal from anaerobic digestion effluents of aquatic macrophytes using the green alga *Chlorella Sorokiniana*.   *Shigeko Kimura*

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In Lake Biwa, Japan, overgrowing aquatic macrophytes cause various environmental problems. Anaerobic digestion is the effective and low-cost treatment of aquatic macrophytes harvested from the lake. However, anaerobic digestion effluent (ADE) contains a high concentration of nutrients, and therefore cannot be discharged due to a risk of eutrophication. Green microalgae have high potential to remove inorganic nutrients from ADE, and also produce potentially valuable biomass, which can be used as an animal feed additive. Therefore, we determined cell growth and nutrient removals by a cultivation of the green alga *Chlorella sorokiniana* with ADEs of two macrophytes, *Egeria densa* and *Elodea nuttallii*.

C. sorokiniana was cultivated in 1) 1× (no dilution), 10×, 25×, 50× and 100× diluted ADEs to determine an optimum ADE dilution for the algal growth, 2) 10× diluted ADE and that with a C-medium to determine presence of inhibitor or lack of nutrients, 3) 10× diluted ADE with the C-medium excluding each one of the elements included in the medium to clarify which element was lacked to reach maximum cell yields, and 4) 10× diluted ADE with magnesium (Mg) to confirm improvement of the cell yields by addition of Mg. In all experiments, the alga was cultivated in a C-medium alone as control. PO_4-P, NH_4-N, and Mg concentrations were measured at initial and final days of the cultivation.

According to our results, 1) *C. sorokiniana* grew well at all diluted ADEs, although the alga never grew at an undiluted ADE. In 10× diluted ADEs, the cell yields reached the highest level among the all dilutions. Therefore, we chose the 10× diluted ADEs for following experiments. In the 10× diluted ADEs, the cell yields were 25-75 % of those of the control, implying that the yields did not reach to the maximum. 2) In the ADEs with C-medium, the cell yields were 2 to 6 times higher than those in the ADEs alone, suggesting lack of some nutrients for algal growth in the ADEs. 3) In the ADEs with C medium excluding Mg, the cell growth and nutrient removal efficiency were less than those in the others and control, suggesting a lack of Mg in the ADEs might limit the algal growth. 4) The cell yields in the ADEs adding just Mg were the same as those in the ADEs with C medium. Although removal rates of PO_4-P and NH_4-N in the ADEs were less than 50 %, those in both ADEs with C medium and with just Mg exceeded more than 80 %. These results suggested that addition of Mg to the ADEs enhanced the algal growth and consequently the nutrient removal efficiency. Meanwhile, Mg concentrations in the ADEs adding Mg at the initial and final days of the cultivation were 3.8 and 3.0 ppm, respectively, indicating that just a few Mg was used for the algal growth. Considering that cell yields in the ADEs alone did not reach the maximum even though 0.7 ppm of Mg was contained, Mg in the ADEs may not easy to use for the algae although the forms of Mg in the ADEs is unknown yet.

43-P   Anaerobic digestion of submerged macrophytes: alkaline pre-treatment enhances the methane conversion efficiency.

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The overgrowth of aquatic weeds causes serious environmental and social problems. For the treatment of harvested aquatic weeds, anaerobic digestion (AD) is prospective as a suitable treatment that recovers biogas from wet organic waste with low operational cost. However, plant biomass including submerged macrophytes have lignocellulose as the main components. Due to the strong structure of lignocellulose, the digestibility of many plant biomass is not high. Therefore, in order to increase the CH_4 conversion efficiency, pre-treatment of submerged macrophytes is required. Submerged macrophytes contain abundant alkali-labile lignin (i.e. hydroxycinnamic acids), indicating alkaline pre-treatment would be effective for delignification from solid fraction of the macrophytes, in order to enhance the CH_4 conversion efficiency. Furthermore, operating temperature of AD is also important, because it regulates microbial activity. In the present study, semi-continuous AD of an alkali pre-treated submerged macrophytes were operated under two different digestion temperatures (37ºC and 55ºC). The microbial communities were also examined by using 16S rRNA gene denaturing gradient gel electrophoresis (DGGE).

For the substrate, lignin-rich submerged macrophyte, *Potamogeton maackianus* was used due to the low CH_4 conversion efficiency. This species is one of the dominant species in Lake Biwa (the biggest lake in Japan), and it is commonly found in East Asia. Alkaline pre-treatment was conducted under NaOH 0.2 g per gram dry-weight, coupled with heating at 80ºC for 3 hours. This treatment performed high lignin removal efficiency of 79%. Semi-continuous AD treatments were conducted for 120 days. Substrate was periodically fed into 4.5-L completely stirred tank reactors with organic loading rate of 1 g-VS L^{-1} day^{-1}.

The CH$_4$ conversion efficiencies of mesophilic AD was enhanced for 65% by alkaline pretreatment. Furthermore, additional 20% enhancement was achieved by thermophilic AD. During the semi-continuous AD, decrease of CH$_4$ production rate was observed approximately after a month of operation, probably owing to the inhibition by dissolved lignin accumulation. Nevertheless, the CH$_4$ production rate recovered and maintained at a high rate after 54 days (mesophilic AD) or 76 days (thermophilic AD).

DGGE showed that the changes of microbial community were corresponded with the variations of the CH$_4$ production rate in both AD temperature. Furthermore, the bacterial and archaeal community structures were different in both temperature. Especially in the thermophilic AD, a remarkable bright bacterial DGGE band appeared after Day 60, which may indicate the increase of bacteria tolerant to high dissolved lignin condition. Drastic microbial community shifts coincided with the deterioration and recovery in CH$_4$ production rate, indicating that microbial acclimation contributed to the recovery of CH$_4$ production.

44. SENSING, SIMULATING, PREDICTING ALGAL BLOOMS IN INLAND WATERS

44-O   Looking toward the future: new technologies and space missions for sensing, simulating and predicting harmful algal blooms.   *Erin Hestir*

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Freshwater ecosystems are among some of the most threatened in the world, facing multiple pressures from changing climate and land use land cover change. Nutrient pollution remains one of the largest pollutant stressors in freshwater ecosystems, often leading to species invasions and potentially harmful algal blooms. Bloom forecasting is emerging as a viable way to predict and manage algal blooms, enabled by big data provided by Earth observations and citizen science approaches. New and innovative remote sensing technologies such as high spectral resolution and lidar imagers, microwave radiometers and radar enable measurements of key environmental parameters needed to establish baseline conditions and improve modeling efforts. These technologies provide direct measurement of physical, biological and biogeochemical conditions that can be used as models to understand estuarine processes and responses to change. We demonstrate that innovative remote sensing technologies, coupled with long term datasets from satellite earth observing missions and *in situ* sensor networks provide the spatially contiguous measurements needed to make "supra-regional" (e.g. large basin-continental scale) assessments of lakes, reservoirs, and their surrounding watersheds. New technologies and space missions will support improved modeling and forecasting of algal blooms.

44-O   Space based monitoring of status and trends of cyanobacteria, chlorophyll and turbidity in inland waters. *Thomas Heege, Philip Klinger, Julian Wenzel*

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Characterizing the actual status of inland waters, identifying trends or understanding emerging problems over the huge number of inland water bodies is challenging with traditional in-situ methodologies only. Earth-observation tools can contribute significantly on a local, trans-national and global scale, if methodologies provide independent and consistent information over a wide range of different water bodies and scales. Relevant ecological questions about the spatial and temporal appearance and dynamics of cyanobacteria, the trophic level or sediments in lakes can be analyzed by use of this monitoring capability.

Such an operational, physics based system, the Modular Inversion and Processing System MIP, is presented and tested for a duration of several years over a variety of different small and large lakes. The system provides globally harmonized measures of turbidity, chlorophyll, organic absorption, and includes also a cyanobacteria indicator for Phycocyanin, from a number of satellite sensors (Landsat 7&8, Sentinel-2, MODIS etc.). It is applied for daily monitoring over Europe and Australia in coarse resolution (500m), and in 10 - 30m resolution for selected regions and lake districts in Florida and Europe with up to weekly sampling intervals. The results are continuously published over the eoApp web application (http://eoapp.eomap.com, or http://eoapp-us.eomap.com), allowing an easy online access to daily measurements and time series at freely selectable virtual stations over lakes in Europe and selected regions globally.

Validation exercises over a wide range of lake types are presented (and online accessible through the eoApp web application). Exemplary seasonal trends over a number of years to prove the consistency of the water quality products are analyzed, and the seasonal appearance of Cyanobacteria on selected lakes and basins presented. The validity range, limitations and actual uses cases in collaboration with water agencies in Europe are discussed.

44-O Bloomalert: an in-situ detection network for cyanobacterial blooms in tasmanian waters.

Christopher Bolch

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Detection and monitoring of cyanobacterial blooms in drinking and irrigation water poses significant risks for human and animal health, and major resource challenges for water management agencies. Here we describe the conceptual approach, design and performance of an *in-situ* algal bloom monitoring network based on commercially available probes/buoys to provide real-time assessment of algal communities for water managers/regulators. In late 2015, we established a network of six telemetered monitoring buoys in Tasmanian inland lakes and water reservoirs regularly affected by blooms of cyanobacteria. The core probe parameters of the network include, temperature, chlorophyll-a, phycocyanin, dissolved oxygen and turbidity, measured at high frequency (15 mins), and received by a central server (UTAS Sense-t) for data processing prior to reporting to water managers via web- or mobile-phone interfaces. The *in-situ* network data is being used for development and validation of satellite detection algorithms to extend monitoring/detection capacity to water bodies outside the network sites. In the future we aim to combine BloomAlert monitoring data with data from other dispersed sensor networks (e.g. Bureau of Meteorology) to develop seasonal risk profiles for water bodies and bloom forecasting capacity.

44-O Continental scale simulation framework for the prediction of harmful algal blooms (CYANOHAB). *Klaus Joehnk* [1] *- Nagur Cherukuru* [2] *- Janet Anstee* [2] *- Barbara Robson* [1] *- Elizabeth Botha* [2]

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Surface water quality in Australia is declining and recurring harmful algal blooms by toxic cyanobacteria species (Cyanohab) are widespread. Cyanohabs impact ecosystem services, harming the health of water ecosystems and limiting recreational and cultural water uses. With current approaches, predicting and managing HABs requires intensive local monitoring and data analysis for each waterbody. With thousands of reservoirs, wetlands and coastal lagoons scattered around Australia, only a few can be managed in this way. To address this, we propose a model-data assimilation framework for algal bloom prediction at the continental scale, combining Earth Observation, in-lake monitoring, and coupled modelling frameworks to allow early detection, forecasting, and scenario simulation of Cyanohabs. The development of a continental scale framework for prediction of harmful algal blooms will transform our ability to manage aquatic ecosystem health in data sparse environments. This project combines recent developments in inland water remote sensing of algal pigments, bio-optical studies, and water quality models for algal blooms in lakes and reservoirs across Australia. Our initial study has focussed on developing model components for using Lake Burley Griffin, ACT, as a case study. Models consist of 1D vertical and 3D coupled hydrodynamic-biogeochemical simulation tools including specific bio-optical algorithms, allowing for fast (1D) simulations suitable for long-term scenarios and detailed (3D) studies for lakes with more a-priori knowledge. We will present simulation results for Lake Burley Griffin and outline the proposed next steps to implement the national framework for the prediction of harmful algal blooms on local, regional, and continental scale.

44-O Meta-analysis of tipping points for outbreaks of population density of cyanobacteria across lakes with different trophic state, circulation type and climate revealed by inferential modelling.

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Meta-analysis was used to search for similarities and differences in physical and chemical threshold conditions that instigate fast growth events of *Aphanizomenon*, *Cylindrospermopsis* and *Microcystis* across Lake Müggelsee (Germany), Lake Wivenhoe (Australia), Lake Kinneret (Israel) and Vaal Dam (South Africa).
Each lake represents a certain lake category in terms of eutrophication level, morphometry and climate. Twenty years of limnological data from each lake were modelled by the hybrid evolutionary algorithm HEA in order to quantify species-specific threshold conditions for each lake category with focus on water temperature, euphotic depth, depth of thermocline, and concentrations of phosphate and nitrate. Effects of interrelationships between the physical-chemical and the biological variables have been avoided by a time lag of 7 days during the modelling process. Resulting thresholds reveal differences between the buoyant non-N2-fixing *Microcystis* and the filamentous N2-fixing *Aphanizomenon* and C*ylindrospermopsis, and* serve as indicators for early warning of fast-growth events of the three cyanobacterial genera in the four lakes.

44-O   Forecasting short-term cyanobacterial blooms in Lake Taihu, china, using a coupled hydrodynamic–algal biomass model.   *Wei Li, Boqiang Qin, Guangwei Zhu*

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Lake Taihu, the third largest freshwater lake of China, provides drinking water supply for 5 million people. Over the last 30 years the lake has suffered from serious cyanobacterial blooms that deteriorate drinking water quality and in some cases have led to serious water supply crises. In order for local government to respond quickly to the onset of a cyanobacterial bloom, it is crucial to forecast the probability, areas and intensity of the bloom. In this paper, an attempt to forecast the cyanobacterial bloom in Lake Taihu is documented. The forecast is based on a short-term cyanobacterial bloom forecasting numerical model which containing a three-dimensional, coupled hydrodynamic-algal biomass model and a probability of bloom occurrence forecasting model. The former model was based on solving the governing equations of the cyanobacterial bloom dynamics in shallow lakes. Unstructured mesh division was used to fit the irregular coastal boundaries where harmful blooms often happened. The finite volume method discretised the governing equations and the conservation laws were preserved. To drive the model, the initial algae chlorophyll-a concentrations were obtained from 18 automatic monitoring buoys and boat survey measurements. Combining calculation and prediction of the hydrological and meteorologic scenarios over the ensuing three days, the dynamic distributions of the algae concentration scenarios in Lake Taihu were simulated. Blooming probabilities were then predicted by a forecast model which included the weight of algal biomass, wind velocity and weather condition. The model was applied to predict the occurrences of the algae blooms of the next three days in Lake Taihu during April to October in 2009-2015. Independent evaluation from remote sensing images and boat survey data showed that the accuracy of this bloom forecasts was more than 80%.

44-O   Monitoring and predicting cyanobacteria blooms in a small urban lake.   *Brigitte Vinçon-Leite [1], Plec Furstenau Denis [1], Peiffer Raphaël [1], Lemaire Bruno Jacques [1], Soulignac Frédéric [1,2], Scriban Arthur [1], Roche Honorine [1], Jiang Xi [1], Dubois Philippe [1], Catherine Arnaud [3], Quiblier Catherine [3], Humbert Jean-François [4], Bernard Cécile [3]*

LEESU, École des Ponts ParisTech, AgroParisTech, UPEC, UPE, Champs sur Marne, France [1] - INRA, Thonon-les-Bains, France [2] - MCAM MNHN, UMR CNRS 7245, Muséum National d'Histoire Naturelle, Sorbonne Universités, Paris, France [3] - iEES-PARIS, UMR 7618 (UPMC-CNRS-INRA-IRD-UPEC-Paris Diderot), UPMC, Paris, France [4]

Small and shallow urban lakes provide many ecosystem services. In the Île-de-France region around Paris, 99% of the lakes have an area lower than 0.5 km^2. In this region, the water quality degradation often leads to potentially toxic cyanobacteria blooms. Health risks generated by these blooms require a regular monitoring and warning systems when the human population is exposed. Besides the time variability of the biomass dynamics, a major difficulty in monitoring

cyanobacteria comes from the heterogeneity of their vertical and horizontal distribution caused by their ecological strategies, by the alternation of thermal stratification and mixing and by surface and internal currents. Warning systems based on measuring buoys have been developed over the past decade. They do not provide information at the scale of the whole lake. In large water bodies, satellite remote sensing is sometimes used. In small water bodies, even if the image spatial resolution has greatly improved recently, the frequency of satellite pass limits an accurate detection of blooms. Furthermore, coupled hydrodynamic-ecological models can help in appraising cyanobacteria biomass at relevant space and time scales. At short time-scale, they can be embedded in early warning systems.

In this paper, we present the implementation of a three-dimensional coupled hydrodynamic-ecological model, combined with continuous field measurements. The study site is a small and shallow lake (0.12 km^2, average depth 2.3m, maximum depth 3m) located 20 km East of Paris, in a recreational park attended by the pupils of the neighbouring very densely urbanized county. Bathing in the lake has been repeatedly prohibited each summer because of cyanobacteria blooms.

Two different datasets are available: 1 a summer survey, conducted since 2005 as required by bathing regulation, which includes the identification of phytoplankton genus and their relative abundance; 2 a scientific survey started in 2015 which includes high-frequency monitoring (5 min) of temperature and chlorophyll and bi-weekly vertical profiles of temperature and main phytoplankton groups.

The main patterns of cyanobacteria dynamics and hydrodynamics are presented. The interannual variability of the seasonal cyanobacteria dynamics is outlined. The impact of the physical forcing is analyzed both at the seasonal scale over the 10-year period and at the daily scale in 2015. The modelling suite Delft3D (Deltares, 2014) was implemented for predicting the cyanobacteria biomass over a 5-day horizon and its transport towards regions of interest, for example a beach. At the short time-scale of the prediction, a main assumption is that cyanobacteria distribution is mainly driven by hydrodynamics. Therefore, in the ecological model, no growth rate but only a global decay rate of cyanobacteria is considered. The hydrodynamic model achieved very good results. The forecasts of cyanobacteria biomass for some typical episodes are presented and discussed.

44-O   Phytoplankton functional type modelling: running before we can walk? a critical evaluation of the current state of knowledge.   *Yuko Shimoda, George Arhonditsis*

Department of Physical and Environmental Sciences, University of Toronto, Toronto, Canada

In the context of aquatic biogeochemical modelling, there is an increasing pressure to explicitly treat multiple biogeochemical cycles and to increase the functional diversity of biotic communities. In this study, we evaluate the capacity of 124 aquatic biogeochemical models to reproduce the dynamics of phytoplankton functional groups. Our analysis reinforces earlier findings that aquatic ecosystem modellers do not seem to consistently apply conventional methodological steps during the development of their models. Although there is an improvement relative to earlier critiques, significant portion of published studies did not properly assess model sensitivity to input vectors; aquatic ecosystem modellers are still reluctant to embrace optimization techniques during model calibration; and assess the ability of their models to support predictions in the extrapolation domain. We also found significant variability with respect to the mathematical representation of key physiological processes (e.g., growth strategies, nutrient kinetics, settling velocities) as well as group-specific characterizations typically considered in the pertinent literature. Cyanobacteria blooms are a major concern for water industries as they represent high risk for human health and economic costs for drinking water treatment, and thus one of the outstanding challenges is to offer credible modelling tools that can serve as early warning systems to assist with the operational control of cyanobacteria blooms. Our study suggests that the derivation of distinct functional groups from fairly heterogeneous planktonic assemblages poses challenging problems. Because of the still poorly understood ecology, we do not have robust group-specific parameterizations that can support predictions in a wide array of spatiotemporal domains. In this context, we argue that the most prudent strategies are the gradual incorporation of complexity, where possible and relevant, along with an open dialogue on how we can mathematically depict the interconnections among different phytoplankton subunits or even how we can frame the suitable data collection efforts.

44-O   Dangerous Dino's: toward an (inter)national risk assessment protocol of HABs in inland waters.

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Health risk assessment of nuisance phytoplankton species in inland waters often only focusses on the incidence of a relatively small number of cyanobacteria species. Generally, cell counts or biomass estimated of the most common toxic species, i.e. the "usual suspects" or "big five", are used to assess the risk for humans and wildlife.

Using monitoring data of inland waters in the Netherlands, we show that also eukaryotic toxic phytoplankton species can occur at high numbers in inland waters, especially in fresh waters prone to saltwater intrusion. In-depth analysis of data on bloom and toxin dynamics from a creek frequented by the paralytic shellfish poison producing dinoflagellate *Alexandrium ostenfeldii* indicate that cell numbers are a poor proxy for health risk. With warmer climates resulting in more saltwater intrusion of inland waters the risk of such harmful algal blooms will likely increase. We lay out the steps that need to be taken for an (inter)national risk assessment protocol for harmful algal blooms (HABs) in inland waters.

44-O   Cyanobacterial bloom dynamics - some lessons from the nineties.   *Bradford Sherman, Phillip Ford, Ian Webster*

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The 1990s was a period of active research into cyanobacterial blooms in Australia. Three large CSIRO-led projects were undertaken in two weir pools and one reservoir covering a range catchment, meteorological and hydrological conditions. These studies examined hydrodynamic-chemical-biological coupling and revealed striking similarities as regards the onset and growth of cyanobacterial blooms.

In all systems, the cyanobacteria population growth did not occur until after the onset of persistent stratification and populations only grew when the mixed layer depth, Z_{sml}, was ≤ 3 times the euphotic depth, Z_{eu}. In the case of river weir pools, a period of time following the onset of stratification was required for the water column to clear sufficiently through sinking of suspended sediment to provide suitable light conditions to sustain cyanobacterial growth (i.e. for Z_{eu} to increase such that $Z_{sml}:Z_{eu}$ ≤ 3). Following the onset of stratification, cyanobacterial populations in all three systems grew at their light-limited rate (0.31 - 0.37 d^{-1}) until either the bioavailable phosphorus was depleted or seasonal deepening of the surface layer resulted in light exposure below the compensation level required for net growth.

There was no evidence of nutrient-mediated population growth rates in these systems. Neither was their any evidence that buoyancy *regulation* conferred any benefit to the cyanobacteria. Positively buoyant phytoplankton (*Anabaena*, *Microcystis*, *Cylindrospermopsis*) occupied the surface layer but were not observed to migrate vertically to exploit light-nutrient gradients in these systems. Surface layer populations remained static until physical processes introduced additional nutrients to the surface layer following which the populations commenced growing.

These systems typically exhibit $Z_{sml}:Z_{eu}$ ~ 2 and metalimnetic maxima in phytoplankton are not observed. For this sort of system, reservoir management measures that target nutrient load reduction can be expected to reduce the average annual cyanobacterial biomass but not necessarily eliminate the cyanobacterial dominance of the population.

44-O   Internal waves and *Microcystis* blooms in Lake Kinneret, Israel.   *Ilia Ostrovsky* [1] *- Sally MacIntyre* [2] *- Tamar Zohary* [1] *- Alon Rimmer* [1] *- Alicia Cortés* [2]

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Physical forcing (e.g. near surface heating and cooling, wind, inflows) moderate in-lake processes, such as short- and long-term water column stratification, internal wave dynamics, the intensity of turbulence, and the vertical extent of mixing. These, in turn, affect the availability of light and nutrients. Phytoplankton species are evolutionary adapted to specific physicochemical conditions, and cyanobacteria, in particular, tend to increase in biomass when the stability of stratification increases. We use time series meteorological and temperature data combined with measurements of chlorophyll *a* and *Microcystis* counts to identify the times during winter and early spring when cyanobacterial biomass increased in the water column of Lake Kinneret, Israel, in 2013. The high resolution thermistor data indicated that the lake was thermally stratified and supported an internal wave field during the period which is generally considered holomictic. When winds were stronger, up and downwelling filled the entire water column at a 12 m deep near shore site. On relaxation of the winds, the amplitude of the internal wave motions decreased. Initially, nocturnal cooling was sufficient to disrupt stratification. However, as solar radiation increased and with it the heat content in the lake,

nocturnal cooling was insufficient to disrupt the stratification, and, if winds were light enough, the internal wave amplitudes no longer caused full up and downwelling at the site. It is under these conditions that the earliest *Microcystis* blooms were found. The blooms disappeared when winds increased along with increased cloud cover which weakened the stratification. By early spring, the abundance of *Microcystis* tripled as near surface stratification intensified and internal wave amplitudes lessened. This previously undocumented link between internal waves and bloom formation increases our ability to predict the development of harmful algal blooms in monomictic lakes in response to climatic changes.

44-O   Tracking the critical eutrophication processes of Lake Prespa (Greece) with the use of biogeochemical indicators.

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The area Lake Lesser Prespa in Greece is internationally acknowledged as an important habitat for endemic species and migratory birds, especially for the Dalmatian and the Great White Pelicans. However the water quality, specifically the accelerated eutrophication over the last years, has been of increasing concern. The lake is strongly influenced by the constant fertilization of the bean monocultures within the lake's watershed and other forms of anthropogenic pressure. Since 2013, a regular water monitoring project is carried out where multiple biogeochemical indicators are studied over temporal and spatial scales in order to provide a systematic diagnosis of the nutrient enrichment processes which stimulate the excessive growth of algae in the lake. Monitoring results obtained directly from the field reveal elevated concentrations of chlorophyll and high densities of cyanobacteria during the summer periods of 2013 and 2014. These outbreaks of cyanobacterial blooms may pose a serious health hazard to wildlife and humans due to the co-presence of microcystins (MCs) which were detected in a range of 25 to 468 µg L^{-1} near the lake shores. The susceptibility of the lake water to nutrient enrichment and warming was studied in a controlled experiment were particularly nitrogen addition was found to enhance the growth of cyanobacteria as well as the production of microcystins (MCs).The monitoring data further show that nitrate enriched water is draining from the agricultural fields mainly through a drainage tile system during the periods of furrow irrigation, while soil phosphorus concentrations have built up to levels that often exceed crop needs. The cumulative nutrient input towards the lake through perennial or seasonal flowing tributaries has locally led to the formation of organic and nutrient-rich sediments where pore-water analysis indicates a prospective nutrient diffusion towards the lake water. The temporal oxygen depletion which occurs at the bottom water layers of the lake in summertime may accelerate internal phosphorus release from the sediments Supplementary field research and experiments have been done in order to estimate such critical nutrient fluxes within the lake system. The biogeochemical knowledge of the complex pathway of nutrient transport along the watershed-lake system can be a helpful tool to guide early water management schemes that can curtail the nutrient inputs towards the lake and therefore regulate the intensities of cyanobacterial blooms.

44-O   Evaluation of environmental factors contributing to the blooming of blue-green algae in Paldang reservoir.

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Fluctuation of water temperature, blue-green algae population and hydrological data of Paldang dam, Chungju dam (located at upstream of Namhangang) and Cheongpyeong dam (located at upstream of Bughangang) were used for evaluating the pattern of blue-green algal blooming in the Paldang reservoir. Study points were center of the Paldang reservoir and 2 influent rivers (Namhangang, Bughangang). Published water quality monitoring data from 2012 to 2015 were used.

All study points showed that elevation of water temperature were correlated weakly with the increase of blue-green algae population (r^2 = 0.31 ~ 0.39). From regression equation between blue-green algae population and water temperature, blue-green algae population was estimated to be about 100 cells mL^{-1} at 21 ℃ ~ 22 ℃ of water temperature. Surveyed water temperature range of blue-green algae proliferation showed 12.6 ℃ ~ 32 ℃ (Paldang reservoir), 9.4 ℃ ~ 32.2 ℃ (Namhangang) and 18.5 ℃ ~ 29.2 ℃ (Bughangang), respectively. In addition, Increase of each dam outflow showed a tendency to lower water temperature.

Correlation between Paldang dam outflow and blue-green algae population indicated weak relationship (r^2 = 0.21). From 800 m^3 sec^{-1} of Paldang dam outflow, frequency of blue-green algae appearance sharply decreased (less than 1 time). In 2012 and 2013, correlation between Paldang dam outflow and blue-green algae population showed strong relationship (r^2 = 0.64, 0.73 respectively). In 2014 and 2015, extremely low dam outflow was observed than 2012 and 2013 (478 m^3 sec^{-1} in 2012, 607 m^3 sec^{-1} in 2013, 234 m^3 sec^{-1} in 2014, 177 m^3 sec^{-1} in 2015, yearly mean basis). These results implied that maintaining the dam outflow more than 800 m^3 sec^{-1} was desirable in order to protect the proliferation of blue-green algae in Paldang reservoir. From regression equation between Paldang dam outflow and blue-green algae population in 2013, blue-green algae population was estimated to be less than 200 cells mL^{-1} at 1,000 m^3 sec^{-1} of Paldang dam outflow.

44-O   High sulfide production related to utilization of organic matters from cyanobacterial bloom biomass in a eutrophic lake.   *Helong Jiang, Mo Chen, Haiyuan Cai*

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Cyanobacterial blooms frequently occur in eutrophic freshwater lakes, subsequently, substantial amounts of organic matters are produced. A majority of the algal-derived organic matters will be utilized by microbial communities in lakes. Bacterial community composition in cyanobacterial phycosphere was highly organized and showed obvious difference from phytoplankton. Furthermore, bacterial communities of different sized aggregates within the cyanobacterial phycosphere varied with dependence on aggregate size. Bacterial species on large and small-size aggregates likely have the ability to degrade high and low molecular weight compounds respectively, possibly operating in sequence and synergy to catalyze the turnover of complex organic matters. After decaying, cyanobacterial bloom biomass settles onto the lake sediments, which led to the occurrence of hypoxia and enhanced sulfate reduction. As a result, a larger amount of total dissolved sulfide (peak values of 5.90±0.36 to 7.60±0.12 mg L^{-1}) in the water column and acid volatile sulfide (1081.71±69.91 to 1557.98±41.72 mg kg^{-1}) in 0-1 cm surface sediments were detected. Moreover, increasing diffusive phosphate fluxes at the water-sediment interface were positively correlated with sulfate reduction rates. As increases in toxic sulfide and phosphate release rates deteriorated the water quality/ecosystem and even spurred the occurrence of black water problem in lakes, organic matters from cyanobacterial bloom needs to be considered in the management and remediation of freshwater ecosystems.

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44-P   Specific detection of cyanobacteria blooms in lakes through remote sensing: the approach of the project BLASCO (Blending Laboratory And Satellite Techniques For Detecting Cyanobacteria).

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Algal blooms can have an impact on health care costs, on the costs associated with the treatment of water intended for human consumption and on the tourism industry. The implementation of early warning systems would reduce these costs and the efforts needed to face and control the harmful effects of an algal bloom. A system for monitoring the quality of the waters, which operates on a large scale and at high frequency, would allow to keep under control the evolution of a bloom. The observation by satellite permits such a monitoring: in particular, the project is focused on the development of techniques for the analysis of satellite images, in order to detect the early stages of bloom formation in lakes and identify the involved phytoplankton taxa. To reach this goal, it is necessary to analyze the characteristic spectral response of cyanobacteria and to develop algorithms to be applied to the analysis of satellite images. Therefore, experimental activities were carried out, using cyanobacterial cultures, to determine taxon specific reflectance and

absorption spectra, as well as a spectrofluorimetric analysis of the phycobiliproteins. Different approaches were applied and compared (HPLC, counting, in vivo fluirimetry, spectroradiometry) to quantify the amount of cyanobacteria.

The analysis of apparent and inherent optical water properties performed in the laboratory let us know in more detail the spectral responses of different photosynthetic pigments which can be found inside cyanobacteria. On the base of this knowledge specific algorithms are actually being implemented, which use the relations between spectral band ratios and algal concentration. These algorithms will allow the real time monitoring of the presence and concentration of cyanobacteria in the water using proximal sensing tools. The same algorithms will be applied to satellite images in order to derive presence/absence and concentration maps of cyanobacteria in the surface layer of lake waters.

The preliminary results of laboratory analysis show that the spectral response of Chlorophyll-a in the 680-720 nm spectral region can change with different stress conditions (e.g. temperature, irradiance and water turbulence) the cyanobacteria has been exposed to.

Field data on water optical properties and phytoplankton samples were also collected during blooms, for the calibration of the specific algorithms to be developed for the interpretation of satellite images.

During the first months of the Project some cyanobacteria blooms occurred in 2015 in Comabbio, Pusiano and Varese lakes, which have been mapped using LANDSAT-8 images and frequency of blooms in the past decades (2002-2012) were analyzed with dedicated algorithm for MERIS images.

44-P   LANDSAT 8 satellite detection of harmful cyanobacteria blooms in Tasmanian inland waters.

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Cyanobacteria blooms in irrigation and drinking reservoirs pose a threat to public health and a significant challenge to water managers. The use of satellite imagery promises to greatly increase the spatial reach of monitoring regimes. This study evaluates the effectiveness of the Landsat 8 and Sentinel 2A platforms in monitoring cyanobacteria biomass in inland waters in Tasmania, Australia. Four in-situ monitoring buoys were deployed in late 2015 in separate lakes and reservoirs to monitor phycocyanin and chlorophyll-a concentrations and other water quality parameters. In-situ radiometric readings were taken from Lake Trevallyn, coincident to Landsat 8 overpass, to evaluate the accuracy of atmospheric correction and to develop new remote sensing models for chlorophyll-a and phycocyanin retrieval. Models were developed using multiple regression and principal component analysis based on satellite bands and ratios. Satellite retrievals based on a four band Landsat 8 multiple regression model show good agreement (R^2=0.66) with in-situ chlorophyll-a measurements taken from Lake Trevallyn which we expect will enable detection of increases in cyanobacteria biomass generally associated with bloom conditions.

44-P   A study of absorption and fluorescence characteristics of cyanobacteria.   *Anna Göritz* [1] *- Peter Gege* [2]

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Over the last decades, remote sensing of chlorophyll pigments has been proven to be a powerful tool for investigating phytoplankton both in the ocean and in inland waters. However, pigment identification as needed for a monitoring of potentially harmful algae blooms still imposes a high challenge to researchers.

Due to their specific pigment composition, cyanobacteria offer optical characteristics that, in principle, allow for a separation from other algae. But these properties are highly variable, which adds strong uncertainty on the identification. For a better characterization and to disentangle different environmental effects on the absorption and fluorescence properties of cyanobacteria, we have developed a laboratory setup that permits us to grow phytoplankton under well-defined light, temperature and nutrient conditions. Changes in the absorption and fluorescence properties are monitored using a double beam spectrophotometer and a fluorometer. Here, we present first findings of our studies in which we investigate the variability of different cultures of cyanobacteria. These studies form the basis for improving bio-optical models used for remote sensing of cyanobacteria.

44-P   Comparison of aggregated trait based versus species resolving models focusing on phytoplankton communities in a vertical water column.   *Frank Peeters, Dietmar Straile*

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Trait based modelling using adaptive traits is considered to be a promising avenue to simulate the development of properties of communities, as it does not require the simulation of numerous species and allows for adaptation. The application of trait based models to the development of phytoplankton communities in lakes requires consideration of the vertical dimension, as important drivers of primary production change with water depth. Assuming a simplified environment with time-constant external forcing, we compare results from an aggregated trait based phytoplankton model using adaptive trait simulations with results from a traditional model resolving a large number phytoplankton species. The spatially resolved models consider competition of light and nutrient limited phytoplankton in a vertical water column. The temporal development of the phytoplankton community is simulated assuming a trade-off between two traits characterizing resource limitation. In the species-resolving model numerous fixed trait combinations are considered to represent different species whereas in the aggregated trait based model mean and variance of the traits are simulated dynamically and considered to represent the functional properties of the phytoplankton community. The model comparison suggests that aggregated trait based models using the commonly applied closure scheme may provide reasonable approximations of total biomass, average community traits and even trait variance of the phytoplankton community, but may fail to capture important properties of the trait distribution that result from the transport by turbulent diffusion.

44-P   Danger of anatoxin- a (s) from cyanobacteria for aquatic ecosystem health.   *Valerii Tonkopii*

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Depending of on the cyanobacterial genera, the associated toxins may include most toxic alkaloid neurotoxins, as anatoxin-a(s)-the natural organophosphorus compound ,which has a unijue N-hydroxyguanidine methylphosphate ester. Anatoxin are mainly produced by cyanobacteria *Anabaena flos-aque* and *A.Lemmermannii*. Anatoxin-a(s) is the only known natural organophosphorus compound with inhibition of cholinesterase (ChE) similar in its action to different synthetic organophosphorus pesticides.
The present study was undertaken with the aim to investigate the toxicity of anatoxin-a(s) and different organophosphorus pesticides in the experiments on *Daphnia* magna and albino mice. *Daphnia magna* from a class of paddle- handed crabs holds a most unique position. This aquatic animal extensively used as a test organism in aquatic toxicology due to their small size, short life cycle and amenability to lab culture. *Daphnia magna* is the most sensitive test-object in relation of different pollutants among all known biological objects including experimental animals. Experiments were performed with a 2-days old culture of *Daphnia* magna. The toxicity of xenobiotics was determined by the value of LC_{50}, a concentration of the compounds causing death to 50% of hydrobionts during incubation with toxicants for 24 hours. During the experiments, hydrobionts were placed in beakers with 25 ml of dechlorinated settled tap water at 18-20°C. In the first stage of the work, toxicity of anatoxin a(s), some organophosphorus pesticides (malathion, dipterex, DFP, paraoxon, armine, DDVP, etc.) was determined. Anatoxin-a(s) was produced by *Anabaena flos-aquae* clone NRC 525-17 and was purified from lyophilized cells. Purification procedure involved extraction with 1.0 M acetic acid, ethanol,column chromatography and high performance liquid chromatography. Also, the toxicity of these compounds in experiments with albino mice following subcutaneous injection of poisons was determined (from the LD_{50} values). Besides, in experiments in vitro we investigated the antiChE activity of compounds using the mice brain and *Daphnias* homogenates as source of enzyme - cholinesterase. The results of experiments demonstrate the absence of correlation between the toxicity of antiChE compounds on *Daphnia* and mice. For instance some organophosphorus pesticides with a very small toxicity on mice differ extraordinary toxicity for *Daphnia*, especially DDVP, dipterex and malathion. This inconsistency can be explained because *Daphnia's* cholinesterase differs from the mice enzyme by its very high sensitivity to organophosphates and especially to anatoxin. The most toxic for *Daphnia* magna and mice from all investigated compounds was anatoxin a(s). Thus the organophosphorus pesticides which are almost untoxic for animal and human at the same time are superecotoxicants for *Daphnia* and aquatic ecosystem health. Most dangerous and toxic was metabolite of cyanobacteria-anatoxin –a(s).

46. LOOKING FORWARD FROM THE PAST: ADVANCES IN LAKE ECOSYSTEM SCIENCE DERIVED FROM PALAEOLIMNOLOGY

46-O Testing ecosystem state change theory using paleolimnology: the case of Lake Winnipeg, Canada. *Peter Leavitt [1] - Lynda Bunting [2] - Gavin Simpson [1] - Bjoern Wissel [1] - Kathleen Laird [3] - Brian Cumming [3] - Ann St. Amand [4] - Daniel Engstrom [5]*

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Eutrophication can initiate sudden ecosystem state change either by slowly pushing lakes towards a catastrophic tipping point beyond which self-reinforcing mechanisms establish an alternate stable state, or through rapid but persistent changes in external forcing mechanisms. In principle, these processes can be distinguished by determining whether historical changes in focal parameters (e.g., phytoplankton) exhibit transient (rising then declining) or continuously-elevated variability characteristic of alternate stable states or a 'paradox of enrichment', respectively. We tested this hypothesis in the south basin of Lake Winnipeg, Canada, a site with intense blooms of N_2-fixing cyanobacteria since 1990, but for which little is known of earlier limnological conditions, causes of eutrophication, or whether modern conditions represent a alternate stable state. Multi-proxy paleolimnological analysis revealed that the basin was naturally mesotrophic (~15-20 μg P L^{-1}) with diazotrophic cyanobacteria, productive diatoms, and phosphorus-rich sediments. Eutrophication accelerated during ca.1900-ca.1990, when sedimentary nitrogen, phosphorus and carbon contents increased 10-50%, $\delta^{15}N$ enriched 3-4‰, and concentrations of many fossil pigments increased 300-500%. Variance partitioning revealed that nearly 75% of 20th century variability was explained by concomitant increases in production of livestock and crops, but not by climate. After ca.1990, the basin exhibited a rapid three-fold increase in akinetes from *Aphanizomenon* and *Anabaena* spp. and 50% declines in pigments from chlorophtyes and cyanobacteria because of sudden socio-economic reorganization of agriculture. Phytoplankton variability quantified using Gaussian generalized additive models increased continuously since the onset of agriculture for bloom-forming taxa, did not decline after state change, and suggested that the new state is not self-reinforcing and that recovery should not be affected by stable-state hysteresis.

46-O Developments in the use of organic matter biomarkers to track allochthonous carbon inputs to lakes. *Jennifer Korosi, Ammar Saleem, Linda Kimpe, Jules Blais*

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Aquatic ecosystems are greatly influenced by terrestrial organic matter inputs, and changes in vegetation, soil decomposition rates and hydrological connections within watersheds have implications for aquatic ecosystem functioning. Consequently, a greater understanding of the long-term trajectory of terrestrial carbon inputs to climate-sensitive northern lakes has been highlighted as an important area for future research. We are exploring the use of organic matter biomarkers preserved in lake sediment cores to reconstruct historical changes in the quantity, composition, and degradative state of terrestrial organic matter inputs to subarctic lakes in the Northwest Territories of Canada. Our research has shown that lignin-derived phenols (organic matter biomarkers derived unambiguously from terrestrial sources) effectively tracked the changes in catchment vegetation and drainage patterns that occurred as a result of peat subsidence. By incorporating lignin-derived phenols into a multi-proxy framework that included subfossil diatoms, macroscopic charcoal, sedimentary mercury, and elemental and stable isotope analysis, we demonstrated that peat subsidence was initiated by a forest fire, leading to a long-term increase in terrestrial carbon and mercury inputs to the lake, and the eventual crossing of an ecological threshold for dissolved organic carbon.
 Lignin-derived phenols are an underutilized tool that can provide important insights into the processes governing the delivery of terrestrial carbon to lakes over long timescales. However, standard methods for analyzing lignin phenols in lake sediments use a pressure bomb, which breaks down complex organic molecules into simpler components, and as a result provides only coarse taxonomic information. The development of gentler extraction methods and sophisticated

analytical techniques would allow for the identification of more complex organic molecules from lake sediments, enhancing our ability to characterize the taxonomic origin of terrestrial organic matter in lakes. We have developed an analytical method using UPLC-Quadrupole time-of-flight (UPLC-QTOF) mass spectrometry that applies techniques traditionally used in plant metabolomics studies to lake sediments. We are currently conducting the first broad-scale assessment of plant-derived chemical compounds preserved in lake sediments from two distinct ecoregions of the Northwest Territories: boreal forest and low-shrub tundra. Using this approach, we can identify novel plant biomarkers to be applied as tracers of treeline advancement and retreat at the catchment-scale. This approach to biomarker discovery can be applied across ecoregions globally, leading to transformative advances in our ability to characterize changes in terrestrial carbon sources to lakes over centennial to millennial timescales.

46-O   Reconstructing trace metal-derived 'palaeotoxicity' from urban lake sediment records.

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Urbanisation and urban populations increased dramatically through the 20th century and are forecast to continue with an estimated 70% (6.4 billion) of people living in urban areas by 2050. Such expansion will inevitably increase pressure on urban freshwater resources both in terms of utilisation and degradation. The use of lake sediment cores as archives of pollutant inputs allows contemporary levels of contamination to be placed in an historical context while combining these records with robust radiometric dating allows not only directions (improvement; deterioration) but, more importantly, rates of change to be determined. However, while urban lakes are common, the scale and extent of contamination in urban freshwaters, are understudied and the potential toxicity of metal mixtures in urban lake sediments is largely unknown especially in a temporal context.

Consensus sediment quality guidelines are widely used for contemporary lake sediments to provide a means by which to determine the probability of risk to aquatic biota from individual contaminants while Probable Effect Concentration Quotients (PEC-Qs) allow effects from multiple contaminants to be assessed. However, these approaches are rarely applied through dated sediment records to provide an historical record of 'palaeotoxicity' and, to our knowledge, this approach has never been applied to urban lake sediments.

Here we present multiple metal (Pb, Cu, Zn, Ni, As) concentrations and PEC-Qs determined for sediment cores taken from six lakes within the Greater London area covering the period from the mid-19th century to 2010. Equivalent data for a range of urban lakes in other UK cities and rural lakes across England were also determined for comparison. Consensus sediment quality guidelines for individual metals and PEC-Q thresholds for all metals in combination were exceeded at all urban sites, often throughout the entire record demonstrating widespread potential toxicity to aquatic biota spanning more than a century. Furthermore, although reductions in concentrations and calculated toxicity have declined since the 1960s, exceedance remains widespread. Lead was found to be the metal contributing most to the PEC-Q at five of the six urban sites, while the other metals contributed similarly. Urban lakes in other cities were also found to exceed guideline values, while by contrast, the rural lakes showed limited, or no exceedance.

We conclude that:

- As our measurements only included a limited number of trace metals, our estimates of toxicity are likely an underestimate, not only as a result of other metals but also from a range of organic pollutants;
- The scale of contamination in urban lakes is both widespread and long-term and, in comparison with rural lakes, severe;
- the scale of contamination stored in urban lake sediments is very large and could potentially become re-mobilised, and available to aquatic ecosystems, if disturbed.

46-O   Using palaeolimnology to address issues of current conservation concern: the case of the common scoter in Northern Scotland.   *Hannah J. Robson*

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The WWF (World Wide Fund for Nature) Living Planet Report (2014) details a worrying 76% reduction in freshwater species globally since the 1970s[1], while the 2013 State of Nature Report suggests declines in Britain of 57% in freshwater and wetland species, 29% of which have declined strongly[2]. The Common Scoter (*Melanitta nigra*) is one such declining

species. Wintering in coastal waters from Mauritania to the Baltic this diving duck breeds near to oligotrophic freshwater lakes in Ireland, Scotland, Iceland, northern Scandinavia and north east Russia. In Scotland breeding numbers have fallen by almost 50% in less than 10 years[3]. In order to implement effective and cost efficient conservation solutions it is vital to disentangle the potential drivers of decline. Palaeolimnology, the study of biotic and abiotic remains in lake sediments, is a little used but nonetheless potentially effective tool for diagnosing the causes of species declines. This study focuses on a key stronghold for the Common Scoter in Britain, the Flow Country in north east Scotland, where annual monitoring indicates a concerning decrease in both total breeding numbers and levels of productivity since the late 1980s.

Short (0.5 m) sediment cores were taken from 18 Flow Country lakes in 2013; from which a subset of four lakes were cored with a wide bore corer in 2015. Set in a mixture of landscape settings, half of the 18 sites continue to support breeding scoters whilst the remainder demonstrate significant reductions or total losses of breeding populations. Multi-proxy analysis of the cores included diatoms, chironmid and macrofossil remains.

Top-bottom analysis of the 18 short cores demonstrated that communities inhabiting these lakes have changed dramatically in recent times; resulting in divergence of community structure, suggesting a range of drivers impacting these systems which were originally relatively homogeneous. Analysis of the four wide-bore cores provided a fine resolution view of ecological change suggesting major changes in Scoter habitat over the last 20-50 years, potentially linked to anthropogenic pressures including afforestation, fishery management and climate change. Disentangling drivers of common scoter decline enables the refinement of conservation management strategies.

This study demonstrates that the conservation management of rare and declining freshwater species such as the Common Scoter can be greatly assisted by a long-term palaeolimnological perspective.

46-O   Spatial distribution of subfossil diatom and chironomid assemblages' in surface sediments of a remote oceanic lake: the case of Lake Azul (Azores Archipelago).

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Until recently, the distribution of diatom and chironomid species assemblages and their attributes (e.g. taxa richness) in relation to water depth have been identified but not quantified, especially in remote oceanic islands. The influence of environmental variables on diatom and chironomid distribution and taxa richness in a deep, monomitic lake in São Miguel Island (Azores archipelago, Portugal) is assessed. Particular attention is given to community variation along lake water depth gradient in which a number of environmental variables abruptly change in Lake Azul. Surface-sediment diatom and chironomid assemblages were collected following three deepening transects along a gentle and abrupt slopes from shallow near-shore to the central deep offshore basin sedimentary environments of the lake, at a resolution of 1 m water depth. Ordinary least squares (OLS) regression was used to test the taxa richness and abundance of diatoms and chironomids in sediment vs water depth. Abundance and taxa richness data were related to 8 limnological variables using multivariate techniques (PCA, dbRDA and DISTLM). A hump-shaped relationship between taxa richness and water depth was noted with a peak occurring at intermediate depth levels (9.0-9.8 m). Water column variables were the most important ones, followed by sediment and geochemistry variables in explaining the distributions of diatoms and chironomids along the depth gradient. Episodic transport from shallow littoral subfossil diatoms and chironomids to deepest slope levels seems to be variable between the different transepts, including differences in transport and deposition processes in lake margin sedimentary environments.

46-O   Characterizing natural and anthropogenic impacts on the ecology of shallow lakes of the Selenga Delta, Lake Baikal, Siberia, using a combined spatial survey and multi-proxy palaeolimnological approach.

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Wetlands are productive transitional systems between freshwater bodies and their terrestrial watersheds. Shallow lakes are often an important component of wetland floodplains, and may comprise up to 50% of the total surface area. Lake Baikal is a World Heritage Site in Siberia, with high levels of biodiversity and endemicity. The Selenga River is the principal source of inflow to Lake Baikal, entering the lake through a floodplain wetland, the Selenga Delta (henceforth "the Delta"). The Delta is a Ramsar Site, and provides crucial habitat for populations of migratory birds and spawning fish due to high levels of habitat heterogeneity. The Delta contains hundreds of shallow lakes with varying levels of connectivity. Twentieth century anthropogenic activities, including agriculture, industry, hydrological modifications, and climate change, have increased the vulnerability of the lake ecosystems. However, the impacts of such stressors on the Delta ecology have never before been assessed. New research from this region, combining contemporary spatial studies and multi-proxy reconstructions from sediments of Selenga Delta lakes, will allow for the examination of ecosystem impacts and sensitivity related to human-mediated pressures.

Fourteen shallow lakes within the Selenga Delta (SLNG) were sampled in August 2014 with the aim of spatially characterizing ecology and pollution of the Selenga Delta region. Sites were chosen to represent both connected and isolated systems. Sediment cores were also collected from one of the lakes, unofficially named SLNG04, for the purpose of conducting a multi-proxy reconstruction. Biological analyses included diatoms and algal pigments, while trace metals and organic pollutants were analyzed to examine the extent of historical and contemporary pollution.

Modern spatial distribution of pigments, total chlorophyll-a (*Chl-a)* concentrations, and diatom communities suggest meso- to eutrophic conditions across Selenga Delta lakes. Smaller, isolated sites are more productive, with higher concentrations of chlorophylls and β-carotene (markers for "total algae"). Trace metal concentrations across the Selenga Delta are low to moderate, with concentrations from smaller, isolated lakes distinct from connected lakes. Spatial variability of trace metal concentrations indicates possible influence of both land-use and hydrology.

Multi-proxy reconstruction from SLNG04 indicates low, but discernable levels of trace metal and organic pollutants present in the lake beginning in the late 1950s. High pigment concentrations occur in the late 1950s/early 1960s, which coincides with very low diatom concentrations and preservation rates. Increases in diatom concentration and total algal production (*Chl-a*) in the past decade are observed. Twentieth century algal community changes likely reflect the influence of hydrology, along with economic development and land-use.

46-O   454-sequencing of sediment microbes in high depth-resolution gives detailed insights in the structure of archaeal communities.

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Sediment microbial communities are influenced by a number of biotic and abiotic factors that vary with sediment depth. We aimed to investigate the influence of intrinsic (chemistry and organic matter quality in the sediment) versus extrinsic (introduced from the pelagial in the past consecutive years) factors on microbial community composition. Comprehensive measurements of environmental parameters and amplicon pyrosequencing using universal SSU rRNA primers were performed in high depth-resolution of sediment cores taken along a small transect in Lake Stechlin (Germany). Here, we focus on two aspects within our results: The dominance of archaeal groups (within Euryarchaeota and Thaumarchaeota) mainly known from marine sediments, related to high pressure and salinity, and the occurrence of methanogenic archaea in all sediment depths in similar percentages, regardless of their typical activity zones. Our results do not suggest that extrinsic factors such as environmental conditions in the pelagial or continuous burial over time explain the vertical arrangement of microbial community composition in the sediment. However, redox gradients, organic matter quality, and interactions with other microbes within the sediment are well related to vertical changes in the archaeal community composition. These results give new insights into sediment depth-related changes in archaeal community structure, and reflect the impact of environmental factors on microbial life in sediments.

46-O   Different performances of independent sediment biological proxies in tracking ecological transitions and tipping points in a small sub-alpine lake since the little ice age.   *Monica Tolotti* [1] - *Andrea Lami* [2] - *Nico Salmaso* [1] - *Handong Yang* [3] - *Manuela Milan* [4]

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A comparative study of independent geochemical and biological proxies was carried out on a short (83 cm) sediment core collected in 2011 from the deepest point of a small subalpine Lake Ledro (Trentino, N-Italy). The aim of the study was to compare the capability of subfossil photosynthetic pigments, diatoms and Cladocera in tracking lake ecological transitions and tipping points related to major environmental perturbations occurred during the last three centuries, i.e. after the culmination of the Little Ice Age in the Alpine region. The comparison was performed by applying Non Metric Multidimensional Scaling (NMDS) coupled with vector fitting. The secular ecological evolution of Lake Ledro was compared with paleoecological reconstructions provided by a recent sediment investigation of Lake Garda, the largest Italian subalpine lake, which is located only a few km SE from Lake Ledro.

The results outlined a pronounced sensitivity of Lake Ledro to hydrological variability throughout the whole time span considered, but especially during the 18th and 19th centuries, and revealed two major stages in the lake ecological evolution, which were mainly controlled by climate related hydrological variability and lake nutrients, respectively. The strong response to hydrological variability is intrinsic for the lake and depends on its peculiar catchment size and morphology.

These results highlight that responses of biological proxies to different natural and human stressors may differ in type, timing and magnitude, and that they are indirectly modulated by lake size, which controls the lake response to climate-related physical perturbations. The three biological proxies showed comparable capabilities in tracking ecological tipping points of Lake Ledro related to both lake hydrology and nutrient variability, while only diatoms demonstrated a certain capability to track changes in water temperature of this lake. Pigments were a less reliable proxy for the reconstruction of trophic evolution of Lake Garda. Conversely, in Lake Garda Cladocera responded more clearly to temperature changes, and diatoms showed a strong response to lake nutrient level, and an indirect response to climate related changes in lake thermal dynamics.

The comparison of the secular evolution of two close subalpine lakes of different size confirmed that lake sensitivity to environmental perturbations is strongly dependent on lake size and morphology, and that planktonic organisms respond to climate variability mostly in an indirect way. This stresses the necessity for lake management strategies to take into account not only the present exploitation of lakes and climate change, but also the lake-specific sensitivities to local forcings.

46-O   Disentangling the competing roles over millennial timescales of climate, land use and natural ecosystem dynamics on lake-water carbon cycling in the Swedish boreal landscape.   *Richard Bindler, Carsten Meyer-Jacob, Sofia Ninnes, Erik Myrstener, Johan Rydberg, Christian Bigler*

Dept. of Ecology and Environmental Science, Umeå Unviersity, Umeå, Sweden

Over the past 30 years environmental monitoring programs in Scandinavia and elsewhere have recorded increasing concentrations of total organic carbon (TOC) in many northern lakes. Hypotheses for this 'brownification', which has implications for drinking water quality and aquatic ecosystem functioning, include recovery from acidification, modern land management and climate change. However, singular focus on recent trends and ongoing processes overlooks the imprint on lake-water quality imposed by long-term human impacts at larger landscape scales. As shown in research on lake acidification, aquatic biodiversity and metal pollution, lake-water quality in Swedish lakes has changed in response to human impacts not only over decadal but also over centennial to millennial timescales.

Research on long-term changes in TOC has focused principally on remote systems largely defined as natural or undisturbed; however, we suggest the evidence from some of these 'remote' areas indicates that lake-water TOC declined over the past 500–2000 years in conjunction with the widespread utilization of the landscape that was characteristic for much of Scandinavia. This historical land use included slash-and-burn agriculture, small-scale

cultivation, outfield and forest grazing, mire haymaking, exploitation of forest resources and in northernmost areas, we also speculate settlement and possibly reindeer husbandry.

To study the influence of this long-term and pervasive landscape utilization on lake-water TOC and trophic conditions we use a multi-proxy approach to identify and explicitly link human impacts to changes in lake conditions. Analyses include pollen and geochemistry to identify changes in catchment vegetation and sediment delivery; diatoms to trace changes in water quality (pH, nutrients); visible–near-infrared spectroscopy (VNIRS) to reconstruct lake-water TOC; Fourier-transform IRS to quantify biogenic silica; and novel techniques including pyrolysis-GC/MS to characterize organic matter composition and analysis of fecal sterol biomarkers as direct proxies for human occupation and animal husbandry. After the initial post-glacial landscape development and build up of soil organic matter and thus also lake-water TOC, studies of Holocene sediment records thus far show only smaller changes in lake-water TOC in response to climate change and natural ecosystem dynamics. However, marked declines in lake-water TOC occur from c. AD 1250 in SW Sweden and c. 1400 in central Sweden in conjunction with an expansion of low-intensive but widespread land-use practices (e.g., forest grazing). We hypothesize these practices led to a decline labile C in soils and mires and thus reduced transfer of C to surface waters. The resulting declines in lake-water TOC (~50%) were greater then the increases in surface-water TOC recorded by monitoring over the past 30 years.

46-O   Reconstruction of holocene encironments in Russian far east using chironomids from lake sediments.   *Larisa Nazarova* [1] *- Bernhard Diekmann* [2] *- Nadezhda Razjigaeva* [3]

Institute for Earth and Environmental Science, Potsdam University, Potsdam, Germany [1] *- Alfred Wegener Institutehelmholtz Centre for Polar and Marine Research, Potsdam University, Potsdam, Germany* [2] *- Pacific Institute of Geography, Feu, Vladivostok, Russian Federation* [3]

At the present state of knowledge, biological indicators from aquatic (e.g., chironomids, diatoms, ostracods, cladocera) and terrestrial environments (e.g., pollen, plant macrorests) are the most reliable proxies, because they react sensitively to climate change and define different aspects of environments, which should be assessed together for reliable reconstructions. The focus of our study is to perform qualitative and quantitative reconstruction of climate and environmental changes in Far-East Siberia during the Holocene, following a multi-proxy study of lacustrine sediment records. To perform the reconstructions we investigate sediment cores from several lakes in central and southern Kamchatka and southern Kuriles. All sites are situated along a norlh-south transect that follows the Kuril-Kamchatka Arc. The Kamchatka Peninsula and Kurile lslands are situated in a very climate-sensitive setting. Climate fluctuations here are driven by complex factors, such as global atmospheric circulation, ocean currents, and tectonic activities.

The analysis of fossil chironomid remains and statistical treatment of chironomid data by the application of a newly developed transfer functions provided inferences of mean July air temperatures (T_{July}) and water depths (WD). To perform quantitative reconstructions we developed a new regional chironomid-based T July inference models (transfer functions), by merging modern North-East Siberian and West-Siberian trainings data sets, developed earlier (Nazarova et al., 2013; Self et al., 2013). We established two robust inference models to reconstruct mean summer air temperatures from subfossil chironomids based on ecological and geographical approaches. The North Russian 2-component WA-PLS model (RMSEP $_{Jack}$ = 1.35 °C, r^2 $_{Jack}$ = 0.87) can be recommended for application in palaeoclimatic studies in northern Russia. Based on distinctive chironomid fauna and climatic regimes of Kamchatka the Far East 2-component WAPLS model (RMSEP $_{Jack}$ = 1.3 °C, r^2 $_{Jack}$ = 0.81) has potentially better applicability in Kamchatka (Nazarova et al., 2015).

Study of composite sediment core recovered from Two-Yourts Lake (Central Kamchatka) reveals four chironomid assemblage zones reflecting four different periods in the Late Holocene. Between 4500 and 4000 cal years BP, the chironomid composition indicates close to modern temperatures (~ 13°C). From 4000 to 1000 cal years BP, two consecutive warm intervals were recorded, with the highest reconstructed temperature reaching 16.8 °C between 3700 and 2800 cal years BP. Cooling trend, started around 1100 cal years BP led to low temperatures during the last stage of the Holocene. Comparison with other regional studies has shown that termination of cooling at the beginning of late Holocene is relatively synchronous in central Kamchatka, South Kurile, Bering and Japanese Islands and take place around 3700 cal years BP. From ca. 3700 cal years BP to the last millennium, a newly strengthened climate continentality accompanied by general warming trend with minor cool excursions led to apparent spatial heterogeneity of climatic patterns in the region. Holocene climatic changes in the Kuril Islands were less marked in comparison to the continental margin and the large islands of the South Russian Far East.

46-P Assessment of contamination level of oxbows based on core sediments in the upper Tisza region, Hungary.   *Zsuzsanna Balogh* [1] - *Sándor Harangi* [1] - *István Gyulai* [2] - *János Tamás Kundrát* [1] - *Béla Tóthmérész* [3] - *Edina Simon* [1]

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Many organic and inorganic contaminants can accumulate in the sediment, so the sediment is useful to study the contamination level of aquatic environment. The study of contamination level of oxbows is an important subject from conservation aspect of wetlands. The aim of our study was to analyses the metal concentrations in sediment cores to assess the contamination level in the Upper Tisza region, in Hungary. Protected (Foltos-kerti Holt-Tisza), fishing oxbow 1 (Vargaszegi Holt-Tisza) fishing oxbow 2, (Szabolcsi Holt-Tisza), fishing oxbow 3 (Tuzséri Holt-Tisza) and sewage contaminated oxbow (Tímári Morotva-tó) were studied. The following elements were measured with MP-AES in sediment cores: Cu, Cr, Ba, Fe, Mn, Pb, Sr and Zn. The pollution index (PI) was used to characterize the sediment enrichment of metal elements in core sediments.

Based on the metal concentrations of sediment the studied fishing, sewage contaminated and protected oxbows were entirely separated from each other using canonical discriminant analysis (CDA). The values of pollution index suggest that there were low level contamination for Ba and Cr in the core sediments of the studied oxbows. The contamination level of Sr was low in the protected oxbow and two fishing oxbows, while in the case of one of fishing oxbows (Szabolcsi Holt-Tisza) and sewage contaminated oxbow moderate level of contamination was found for the Sr. The contamination level of Cu was high in the protected and fishing oxbows and moderate level of contamination was found in the sewage contaminated oxbow. In case of Zn the contamination level was high in two fishing oxbows. Moderate level of contamination was found in protected, fishing (Vargaszegi Holt-Tisza) and sewage contaminated oxbow for Zn. Based on the Mn and Fe contamination level all oxbows were characterized with moderate level of contamination. The contamination level of Pb was high in the studied oxbows, except the protected oxbow which was moderately contaminated.

Our findings demonstrated that the effects of anthropogenic activities are caused markedly differences in the contamination level of oxbows based on sediment cores. Our result demonstrated that the sediment is a useful tool to assess the effects of anthropogenic activities on toxic element concentrations of oxbows.

46-P Lake Narlay (Jura Mountains) a paleolimnological reconstruction over the last 1200 years based on algal pigment and fossil diatoms.   *Andrea Lami* [1] - *Simona Musazzi* [1] - *Simon Belle* [2] - *Laurent Millet* [2]

Institute of Ecosystem Study, ISE CNR, Verbania, Italy [1] - *UMR CNRS 6249, Laboratoire de Chrono-environnement, Université de Franche-comté, Besançon, France* [2]

Lake Narlay (46°64N, 5°91E) is located in the Jura Mountains of France at 748 m a.s.l. It is a small, hard-water lake with a maximum water depth of 40 m. The bedrock of the drainage area is composed of Jurassic and Cretaceous carbonate. The catchment area is relatively small and consist of forest (62%), agriculture (34 %) and urban area (5 %). It lacks a permanent inlet and loses water to underground seepage. Water-column circulation is not complete every year, and consequently the lake bottom water have extended anoxic condition. The lake has become eutrophic, with bloom of *Oscillatoria rubescens* because of direct wastewater discharge that occurred in the period 1920-1980.

Previous results on sediments analysis have documented a differential response of the lake to the environmental changes that occurred in AD 1600 when major shift in the trophic reliance on methane of the benthic food web were observed. In the early twentieth century, an intensification of modern agriculture, including construction of a piggery and establishment of a cheese making facility, contributed to the more recent change. However, the lake showed pronounced changes in an earlier stage that remained unanswered. In this poster we aim at reconstructing in more detail the limnological conditions of this Lake over the last 1200 yrs. using combined analyses of specific algal carotenoids and subfossil diatom remains. A comparison with other proxies (chironomid, pollen, and instrumental climatic reconstruction) will be used to better identify, between the complex combination of climate and anthropogenic pressure, the driving factors that determined the ecological trajectory of Lake Narlay.

46-P   Environmental changes in a floodplain island based on diatom succession.   *Daiane Ruwer, Nicolli Osório, Liliana Rodrigues*

Nupelia, State University of Maringa, Maringá, Brazil

Floodplains are present throughout almost all the rivers and their direct relationship with the hydrological dynamics reflects a great diversity of ecosystems. Due to variation in water levels and sedimentation, these ecosystems are in continuous geomorphological, abiotic and biotic changes. Paleolimnological data and analysis of proxies are highly complementary to assess the evolution history of an environment, together with geomorphological analysis. We studied the history of environmental changes in an island located in the Paraná River floodplain (Brazil), through sedimentary and fossil diatoms analyses. We tested the hypothesis that the abundance and composition of diatoms respond to environmental changes that can be perceived by sediment study. We analyzed the particle size, structure, composition and color of sediments and diatom assembly of are core of 2m divided in layers of 2.5cm and dating 760 years by^{14}C. The paleoenvironmental interpretation obtained from the sedimentary faces was characterized the history of the environment in three periods: lake, transition period and swamp, characterized by 760, 300 and the last 150 years respectively. Analyses of the composition and abundance of fossil diatoms divided the record into three time periods that coincided with events during the history of the environment. *Eunotia camelus* and *Eunotia* cf. *pseudosudetica* were abundant in the lake period. Most species of the genus *Eunotia* are characterized by adherence by mucilage pad, are commonly found in lentic, acid and oligotrophic waters. For the transition period *Diadesmis confervaceae* was the most abundant taxa, characterized by epiphytic habit, usually found in shallow environments, lentic and oligotrophic waters with higher temperatures, conditions expected in an environment as lakes and swamps. At the swamp zone, the assemblage was dominate by oligotrophic and benthic taxa *Staurosirella pinnata* and *Luticola simplex*. Species of the genus *Luticola* are typical of soil and moss habitats such as swamps. The adherence by stalks of *S. pinnata* and the benthic habit of *L. simplex* may facilitate their occurrences in habitats with a great vegetation cover and low light as occurs in swampy environments. The dominance of small species in earlier periods might be related to their high surface-to-volume ratio with higher specific growth rates, which may confer a competitive advantage under low nutrient conditions, as this species indicates. We conclude that diatom assemblage studies complement the geomorphological studies and helps understanding past processes in the ecosystem, confirming our hypothesis. Therefore, we observed that the changes of diatom can be a response to the processes operating in the local. This study provides the first paleolimnological reconstruction in a floodplainin Brazil and highlights the importance of hydrological changes as drivers of diatom assemblage and your relevance to understand the past, present and future of environments.

46-P   Analysis of chemical composition and biogeochemical properties of lake sediments from Romanian plain.   *Ioan Alin Bucurica [1] - Ioana Daniela Dulama [1]- Petre Bretcan [2] - Dan Tanislav [2] - Cristiana Radulescu [3] - Claudia Stihi [3] - Sofia Teodorescu [1]*

Multidisciplinary Scientific And Technologic Research Institute, Valahia University Of Targoviste, Targoviste, Romania [1] - Geography Department, Valahia University Of Targoviste, Targoviste, Romania [2] - Faculty Of Sciences And Arts, Valahia University Of Targoviste, Targoviste, Romania[3]

Sediment sequence in lake represents information about the activities within the lake and in its catchment area over a period of time since its inception. This study aims to determine the elemental composition and the morphological structure of lakes sediments collected from the Romanian Plain, in order to characterize their origin and evolution. Concerning the chemical composition and origin of the salt lakes from Romanian Plain, there are several hypotheses, such as: remnants of the Pliocene lake; water supply from underground source arising from subcarpathic salty area; water supply from underground through capillarity involve the salts that are in the clays situated near of the soil surface. Sediment cores were collected from tree lakes (i.e. Amara Lake, Câineni Lake and Movila Miresii Lake) in August 2015. The sediments were collected from shallow depths of water, 1 to 3 m by means of a floating platform, using the piston corer, and then the samples were transported on ice and stored in a freezer at -18 ° C. The sediment column was cut longitudinally, analyzed by microscopy and digital photographed. Volumetric sampling was continuously performed for the composite profiles with 2 cm resolution. The qualitatively and quantitatively determining of chemical composition and distribution of elements on the surface of samples, as well as the surface morphology of sediments was performed by using scanning electron microscope (SEM) SU-70 Hitachi, coupled with an energy dispersive spectrometer (EDS). The biogeochemical properties of sediments were achieved by Fourier transform infrared spectroscopy (ATR-FTIR) using a VERTEX 80/80v spectrometer. Thus, this technique can provide information on a wide range of organic and minerogenic

components, e.g., carbohydrates, humic substances, silicates and carbonates. This information is of particular interest for paleolimnological studies because lake sediments are commonly composed of a mixture of various organic and minerogenic compounds originating from the fossilization of tissues and skeletons of aquatic organisms and from the erosion of lake soils. Analysis for a suite of metals rather than just target anthropogenic metals (e.g., Pb, Cu, Zn, Mn, Cd, Fe) was performed by using an iCAP™ Q ICP-MS and allows for interpretations about the sources for different chemicals. High content of several elements including Cu, Fe and Zn in sediment samples is correlated with their sources and it is possible to identify situations that are a priori favorable or not for tracing of these elements using the isotopic approach

46-P A long-term multi-proxy record of varved sediments suggests climate-induced mixing-regime shift in a large hard-water lake ~5000 years ago. *Walter Finsinger [1], Thierry Fonville [2], Emiliya Kirilova [3], Andrea Lami [4], Piero Guilizzoni [4], André F. Lotter [5]*

ISE-M (UMR 5554), CNRS, University Montpellier, Montpellier, France [1], Palaeoenvironmental Laboratory of the University of Southampton (PLUS), Geography and Environment, University of Southampton Highfield, Southampton, United Kingdom [2], Palaeoecology, Department of Physical Geography, Utrecht University, Utrecht, Netherlands [3], Institute for Ecosystem Study. ISE CNR, Verbania, Italy [4], Institute of Plant Sciences and Oeschger Centre for Climate Change Research, University of Bern, Bern, Switzerland [5]

The long-term terrestrial and aquatic ecosystem dynamics spanning between approximately 6200 and 4800 cal BP were investigated using pollen, diatoms, pigments, charcoal, and geochemistry from varved sediments collected in a large stratified perialpine lake, Lago Grande di Avigliana, in the Italian Alps. Marked changes were detected in diatom and pigment assemblages and in sediment composition at ~4900 cal BP. Organic matter rapidly increased and diatom assemblages shifted from oligotrophic to oligo-mesotrophic planktonic assemblages suggesting that nutrients increased at that time. Because land cover, erosion, and fire frequency did not change significantly, external nutrient sources were possibly not essential in controlling the lake-ecosystem dynamics. This is also supported by redundancy analysis, which showed that variables explaining significant amounts of variance in the diatom data were not the ones related to changes in the catchment. Instead, the broad coincidence between the phytoplankton dynamics and rising lake-levels, cooler temperatures, and stronger spring winds in the northern Mediterranean borderlands possibly points to the effects of climate change on the nutrient recycling in the lake by means of the control that climate can exert on mixing depth. We hypothesize that the increased P-release rates and higher organic-matter accumulation rates, proceeded by enhanced precipitation of iron sulphides, were possibly caused by deeper and stronger mixing leading to enhanced input of nutrients from the anoxic hypolimnion into the epilimnion. Although we cannot completely rule out the influence of minor land-cover changes due to human activities, it may be hypothesized that climate-induced cumulative effects related to mixing regime and P-recycling from sediments influenced the aquatic-ecosystem dynamics.

46-P Paleoenvironmental reconstruction of two karst lakes in the northern neotropics using multiple aquatic bioindicators. *Paula Gabriela Echeverría Galindo [1], Fernanda Charqueño [1], Lizeth Carolina Pérez Alvarado [2], Socorro Lozano [2], Alexander Correa Metrio [2], Itzel Sigala [3], Minerva López [3], Mark Brenner [4], Jason Curtis [4], Sergio Cohuo [5], Laura Macario [5], Antje Schwalb [5]*

Instituto de Ciencias del Mar Y Limnología, Universidad Nacional Autónoma de México, México, Df, Messico [1] - Instituto de Geología, Universidad Nacional Autónoma de México, México, Df, Messico [2] - Instituto de Ciencias Biológicas, Universidad Nacional Autónoma de México, México, Df, Messico [3] - Department of Geological Sciences, University of Florida, Gainesville, Fl, United States [4] - Institut für Geosysteme und Bioindikation, Technische Universität, Antje Schwalb, Germania [5]

Lake Amarillo (830 masl) in the Lacandon forest, southern Mexico and Lake Petén Itzá (110 masl), northern Guatemala, are located in one of the largest karst regions of the world. These aquatic ecosystems lie at different elevations and display unique combinations of environmental variables, which explain their high diversity. Both water bodies are well suited to study past climate and environmental change in the Neotropics, given their locations, depths, relatively rapid sedimentation rates, and the fact that both are "closed-basin" lakes. Previous environmental

reconstructions for the study area relied on a single taxonomic group, and no investigation has used multiple, sensitive "paleo" bioindicators. Moreover, bioindicator-based environmental inferences for the Holocene have not yet been undertaken for ancient Lake Petén Itzá, because research has focused on older (Pleistocene) sedimentary sequences from the basin. Similarly, there are few paleoenvironmental reconstructions in the Lacandon region, and those involved only ostracodes. Recent sampling have showed that other groups, including gastropods and testate amoebae are plentiful in these karst aquatic ecosystems, but they have not been applied as paleobioindicators in the region. The main objective of this study is to provide high-resolution Holocene paleoenvironmental information from mid-elevation Lake Amarillo and low-elevation Lake Petén Itzá. We identified and quantified abundances of ostracodes, testate amoebae and gastropods in long, dated sediment cores from each lake. We will use transfer functions to quantitatively reconstruct past changes in lakes conductivity and water levels. Preliminary results suggest that the main variables affecting community composition and organism abundance are temperature, conductivity and lake level. Reconstructions from both lakes will be used to explore differences in community composition at two different elevations, and investigate past environmental changes. This study for the first time combines biological and ecological information from three taxonomic groups with different sensitivities to environmental variables, which will enable more reliable paleoenvironmental reconstruction.

48. AFRICAN FRESHWATERS: STATE, TRENDS, AND MANAGEMENT OPTIONS

48-O   A global view on future major water engineering projects. *Klement Tockner [1] - Ana Koska [1] - Christiane Zarfl [2]*

Leibniz-institute of Freshwater Ecology and Inland Fisheries, IGB, Berlin, Germany [1] - Eberhard Karls Universität Tübingen, Center for Applied Geoscience, Tübingen, Germany [2]

Human activities have altered how the world functions. During the past decades, we have globally, fundamentally, in the long-term, and in most cases irreversibly modified the geosphere, hydrosphere, atmosphere, and particularly the biosphere. And we are just at the beginning of this new epoch, often referred to as the Anthropocene. Indeed, there is general agreement that the transformation of our globe takes speed, with consequences that may threaten our own survival. We are probably not even able to imagine, or at least it sounds like science fiction, which alterations we will face in the coming decades to centuries.
In this presentation we will provide a comprehensive albeit in no case complete inventory of future major engineering projects that are either planned or under construction in freshwater systems worldwide. We focus on very large dams, major interbasin water-transfer and navigation projects, as well as on large-scale restoration schemes. The main goal is to raise awareness about the immense dimensions of and the challenges associated with future megaprojects. We discuss opportunities to mitigate the consequences of megaprojects based on the lessons learnt from projects in other infrastructure sectors.

48-O   How climatic and anthropogenic changes in hydrology affect tropical river biogeochemistry.
Alissa Zuijdgeest [1] - Bernhard Wehrli [1]

Institute of Biogeochemistry and Pollutant Dynamics, Eth Zürich, Zürich, Switzerland [1]

Natural, seasonal variability in river discharge in many parts of Africa results from the movements of the Intertropical Convergenze Zone. In the upstream reaches of the Zambezi catchment, a pronounced peak discharge shortly after the termination of the rainy season tapers back slowly to dry-season low flow conditions. As a consequence of these varying water levels, the Barotse Plains in Zambia is flooded once per year.
The hydrological seasonality appears to be the driving force behind the biogeochemical variability throughout the year in this river-floodplain system. We will present the seasonal behavior of biogeochemical parameters, including oxygen, carbon dioxide, dissolved organic carbon, and suspended matter, and discuss how their concentrations and loads are linked with the hydrology of the system.
The intricate linkage between carbon cycling and water levels raises the question how changing climatic conditions and anthropogenic alterations of the hydrological regime would affect the riverine carbon cycling. The analyzed scenarios, including climatic variability, expanding irrigation and hydropower operations, illustrate downstream effects on carbon transfer, transformation, and CO_2 emissions.

48-O   Sediments as witnesses and archives of heavy metal load to water bodies in Northern Namibia.
Peter Casper

Leibniz-institute of Freshwater Ecology aand Inland Fisheries, Department of Experimental Limnology, Stechlin, Germany

Namibia is one of the most arid countries in Africa, south of the Sahara. Low precipitation (<500 mm/a) coupled with high evaporation (>2000 mm/a) lead to a water deficiency. In the northern part, where nearly half of the Namibian inhabitants use to life, water is available, mainly from the Kuene and Cuvelai basins. Etosha National Park (ENP), one of the oldest wildlife parks in the world, receives periodically water from the northern systems in the Oshikoto region. The central part of the ENP, the Etosha pan (4,760 km²) is sometimes filled with water, while it dries out to different levels in other years. A high number of various game, concentrated in the pan, is a touristic attraction with high economical significance for Namibia. Presence and activity of wildlife depend strongly on availability of water. Quality of water is an

important issue in managing the ENP. The rivers Ekuma and Oshigambo are connecting the Etosha pan with the northern water systems, which can be impacted by anthropogenic activities. Any sources of a potential load to the ENP would originate from the northern sites and would be transported by the rivers.

An assessment of the heavy metal content in sediment cores was performed along the water transport pathways. For this reason, sediments were collected (i) in Oshanas (ponds connected by small streams) in the Oshakati region, (ii) in Lake Oponono, a system located north of EPN acting as sedimentation trap, (iii) in the rivers Ekuma and Oshigambo at the northern border of the park, and (iv) in the Etosha pan. Sediments were taken using plastic liner, sliced and dried at site; the heavy metal content was analysed in Germany.

At most sampling locations cores up to 10-15 cm length could be taken. Concentrations of heavy metals were similarily low in all samples on spatial and temporal (sediment depth) scales. From this results any source upstream ENP seems very unlikely.

Management of multiple water uses in the region north of Etosha National Park needs to consider measures to secure water quality for the health of the pan and the wildlife living there.

48-O   Physico - chemical changes in the two rift valley lakes Bogoria and Nakuru, Kenya, over a period of 16 months including an extreme drought.

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The physico-chemical properties of surface water samples from the two athalassic endorheic lakes Bogoria and Nakuru in Kenya were analysed in weekly intervals between July 2008 and October 2009. The following parameters were determined: pH, salinity, electric conductivity, dissolved organic carbon (DOC), the major cations (FAAS and ICP-OES) and the major anions (IC), as well as certain trace elements (ICP-OES). In addition samples of superficial sediments were taken in October 2009 and examined using Instrumental Neutron Activation Analysis (INAA) for their major and trace element content including rare earth elements (REE). Both lakes are highly alkaline with a dominance of Na >K> Si > Ca in cations and HCO_3 > CO_3 > Cl > F > SO_4 in anions. Both lakes also exhibited elevated concentrations of Mo, As and fluoride. Due to an extreme draught from March to October 2009, the water level of Lake Nakuru dropped significantly. This created drastic evapoconcentration, with the total salinity rising from about 20‰ up to 63‰. Most parameters (DOC, Na, K, Ca, F, Mo and As) increased with falling water levels. A clear change in the ratio of low mass molecules to high mass molecules (E_{250}/E_{365}) in DOC was observed, contradicting the assumed positive correlation of salinity and this ratio, leading to the necessity for further investigations in this field. Anyway, the change in this DOC "quality" was followed by an almost complete depletion of dissolved Fe from the water phase, leading to the assumption that Fe(III) was released from chelating agents followed by hydroxide formation and then precipitation. In Lake Bogoria the evapoconcentration effects were far less pronounced (total salinity changed from about 40‰ to 48‰). The distributions of REE in the superficial sediments of Lake Nakuru and Lake Bogoria show a high abundance of the REE, corresponding to their volcanic geological background and a very distinct Eu depletion of Eu/Eu* = 0.33–0.45.

48-O   Lake Turkana and Lake Naivasha: fish as bioindicators for trace element pollution from two contrasting rift valley lakes, Kenya.

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Lake Turkana and Lake Naivasha are two freshwater lakes in Kenya that differ significantly in water chemistry and anthropogenic influence: whereas Lake Turkana is believed to be rather pristine and unpolluted, Lake Naivasha is seen

as heavily influenced amongst others due to agricultural activity in the surrounding areas. During the last years a major rise in the water level of the lake has been observed.

This study presents the distribution of selected trace elements in water, sediments and fish tissues from these two lakes. We have included the red belly tilapia *Tilapia zillii* and the elongated tigerfish *Hydrocynus forskahlii* from Lake Turkana as well as the blue spotted tilapia *Oreochromis leucostictus* and common carp *Cyprinus carpio* from Lake Naivasha. Sediments and water samples of Lake Turkana did not show any sign of trace element pollution at least for the sample area in the central basin of Lake Turkana, while Lake Naivasha showed slightly elevated levels of most trace elements in the sediments compared to L. Turkana.

In the muscle of *H. forskahlii* from Lake Turkana and *O. leucostictus* from Lake Naivasha high levels of cadmium and zinc, amongst others, have been detected, presenting risks for human consumers of these fish.

A positive correlation between cadmium and zinc content in muscle has been observed. This might be due to the blockage of zinc-containing enzymes leading to their enhanced expression and therefore leading to elevated zinc levels in muscle.

Furthermore, the results show that the trace element levels in fish seem to correlate with the intensity of land use around the water bodies or more precisely, the usage of mineral fertilizers, which usually contain elevated levels of several trace elements, including Cadmium; highest levels of Cd and Zn, presenting a high risk for fish consumers, were found in *O. leucostictus* from Lake Naivasha. Because of the major change in water level we examined *C. carpio* five years after the sampling of *O. leucostictus*, which did not show those high levels anymore, leading to the necessity of further investigation.

Second highest levels were present in *H. forskahlii* from Lake Turkana, which is exposed to heavily influenced waters only seasonally during migration into the highly influenced delta of the Omo River. This clearly points out that knowing migratory pattern of the fish species is one of the basic requirements for evaluating its suitability as a bioindicator for trace element pollution.

48-O   Carbon inputs from pelagic and littoral sources support energetic demands of Nile Tilapia in three tropical lakes (Ethiopia).   *Tadesse Fetahi [1] - Karl-Otto Rothhaupt [2] - Frank Peteers [2]*

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A comprehensive analysis of food webs requires identifying food sources that support the production of all major organisms within the food web. Here we use stable isotope ratios ($\delta^{13}C$, $\delta^{34}S$ and $\delta^{15}N$) to assess the relative contribution of different basal carbon sources to the diet of Nile tilapia (*Oreochromis niloticus L.*) in three tropical lakes Awasa, Ziway and Koka (Ethiopia). Computations were carried out with SIAR model (Stable Isotope Analysis in R) to quantify the dietary proportion of each prey for the tilapia fish. Basal food sources were distinguishable based on their $\delta^{13}C$, $\delta^{34}S$ and $\delta^{15}N$ values. In Lake Ziway, macrophytes (64%) were the dominant assimilated diet of tilapia while POM and zooplankton contributed only 20% and 16%, respectively. In parallel, Nile tilapia in Lake Awasa assimilated macrophytes (35%), POM (33%) and zooplankton (32%) at comparatively equal proportion. The dominant dietary sources of the fish in Lake Koka were POM (49%) and zooplankton (51%). In contrast with earlier studies based on gut content analysis, the present results reveal that macrophytes contributed more and phytoplankton less than previously reported especially in macrophytes dominated lakes Ziway and Awasa. Macrophytes, which are subjected to human intervention and modification in the country, should be given due attention for the overall sustainable utilization of the lake resources.

48-O   Structure of stream macroinvertebrate communities in a tropical biodiversity hotspot: biodiversity, regional occupancy, niche characteristics and environmental correlates.   *Francis Arimoro [1] - Jonathan Tonkin [2] - Peter Haase [3]*

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Exploring and describing biodiversity and the structuring mechanisms is fundamental to advancing ecology. This is particularly pertinent in understudied regions, such as the Afrotropical biogeographic region, characterised by strong seasonal climatic shifts. We investigated the characteristics of stream biodiversity in the Niger Delta region of Nigeria, a tropical biodiversity hotspot, by examining patterns in 20 stream invertebrate communities across both the wet and

dry seasons. For this, we took a multi-faceted approach accounting for the three levels of biodiversity (alpha, beta and gamma), including partitioning the nestedness and turnover components of beta diversity, regional occupancy-abundance patterns, niche characteristics, and the environmental drivers of community structure. Alpha diversity was low in these streams, with strong turnover between sites leading to high beta diversity contributing to regional biodiversity, but there was little variation in communities between seasons. The proportion of sites occupied declined with increasing niche position, and increased with increasing niche breadth, and occupancy was predicted well by a combination of these two factors, but not mean local abundance, as the abundance-occupancy link was an upper-limit unimodal relationship. On average, environmental variables were linked more strongly to community structure in the wet season. Our findings demonstrate the clear role of spatial, but not temporal, turnover in assemblages, which likely reflects the environmental heterogeneity of this region. This is further supported by the fact that regional occupancy was mostly related to niche characteristics, particularly niche position. We emphasise the importance of continued basic and applied ecological work in this important biogeographic region to enable better protection of its biodiversity.

48-O   How can the ecological health of Kenya's running waters be measured at a time of increasing demand upon them?   *David Harper [3], Nic Pacini [1] - Lydia Biri [2] - Ahmed Al Jasimee [3]*

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Water is essential to life and, in the Naivasha catchment, most lives depend upon surface waters for domestic consumption, yet nothing is known about the ecological health of surface waters. Biodiversity is the critical underpinning of all ecosystems in the catchment, yet almost nothing is known about the biodiversity of rivers.
Catchment streams of Naivasha have been surveyed for invertebrates using standard field techniques (quantitative collections using Surber samplers within defined habitats.)
Samples were identified to lowest taxonomic level using the Keys for South African invertebrates recently published.
Taxa were enumerated by each habitat and habitat data then combined to provide comprehensive site data.
Habitat data were then used to produce biodiversity maps and abundance information.
Site data were then used to develop biological water quality indices
The results are evaluated against the limited existing knowledge of Kenya's running waters.

48-O   Unpredictable, highly variable and totally misunderstood: managing environmental flows in ephemeral rivers in Southern Africa.   *Marinda Avenant, Maitland Seaman, Steve Mitchell*

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The failure to recognise the unique features of non-perennial (NP) rivers, together with a shortage of hydrological and ecological data and an incomplete understanding of the processes driving these systems, has often in the past resulted in poor and inconsistent management. Mostly, inappropriate methods, developed for use in perennial rivers, have been applied to these systems, contributing to their degradation. Non-perennial rivers are unique aquatic systems, distinguished mainly by their variable hydrological regimes, and by the perodic loss of surface water connectivity, leaving the river bed dry, save for isolated pools.
The South African National Water Act requires that an environmental reserve be determined for each significant water body before water-use licenses are issued. Previous studies showed that existing environmental water requirement assessment methods (EWRs) used for perennial rivers are ill-suited for use in NP rivers. Many streams in southern Africa have intermittent flow, mainly due to the variable and unpredictable climate prevailing over much of the region. With the climate expected to become warmer, drier and even more variable over large parts of southern Africa, the pressure to provide freshwater with an acceptable degree of assurance to a growing population in a semi-arid environment, is increasing.
A multi-disciplinary team under the leadership of the Centre for Environmental Management has recently completed a project developing a dedicated methodology for determining EWRs in NP rivers. The method, DRIFT-Arid, was developed over a period of eight years and is based on knowledge gained working in ephemeral rivers. It is a comprehensive, multi-disciplinary approach that captures specialists' knowledge of a catchment in a structured database that is then used to predict the ecological and socio-economic impacts of future flow management options. Central to the method is the selection of a range of indicators that captures the unique attributes of a river ecosystem.

Predictions are then made on how indicators are likely to respond to changes in the flow regime, as well as to changes induced by other indicators, under future flow scenarios. This approach was successfully tested on an ephemeral tributary of the Orange River, the Seekoei, and a near-perennial tributary of the Limpopo River, the Mokolo. Initial results are promising, but need further development.

This contribution specifically refers to the role of fish communities in assessing the EWRs in NP rivers. Fish communities were historically the centrepiece of EWR assessments. The practicality and usefulness of including fish as an indicator in southern African NP rivers should, however, be assessed. Fish communities in these systems are often depauperate and hardy with generalised environmental requirements. Associated constraints, including difficulties with using score-based methods, are discussed and the inclusion of fish in the suite of indicators is motivated.

48-O "Between a rock and a hard place": the complexities of using periphyton as a biomonitoring tool in non-perennial, regulated rivers in central South Africa.   *Tascha Vos* [1] - *Carin Van Ginkel* [2]

Centre for Environmental Management, University of The Free State, Bloemfontein, South Africa [1] *- CRIPSIS Environment, Consultant, Pretoria, South Africa* [2]

Conventional river biomonitoring indices have been developed for perennial systems, which are markedly different ecosystems than the less stable aquatic ecosystems associated with the non-perennial rivers found throughout the more arid parts of the world. Non-perennial rivers in central South Africa have added complexity in that they are regulated systems.

The central region of South Africa is arid with average rainfall of between 400-600 mm/yr. Evaporation far exceeds precipitation, which makes the maintenance of scarce freshwater resources crucial for fostering healthy aquatic environments and sustaining the approximately 3.5 million people and their economic activities. With broad climate change trends pointing towards desertification in this region, the need to replace or complement conventional biomonitoring tools with more context-sensitive tools is imperative.

The general aim of this research was, therefore, to investigate epilithical periphyton as such a biomonitoring tool. The specific objectives were to evaluate the position of periphyton (as a group) as a biomonitoring tool, and identify which of its components would be best suited as indicators of water quality. While diatoms are already used as part of the current biomonitoring toolbox, it is a highly specialised, time consuming and expensive application and not best suited for everyday use in the developing world. In contrast to using diatoms, epilithical periphyton, found on submerged rocks, bedrock and other hard places, is easily accessible for analysis – especially with the chlorophyll-*a* component of periphyton.

This research was conducted over two periods of 24 months on the Modder River and Renoster Spruit (stream), part of the catchments sustain large parts of central South Africa. Physico-chemical factors (including chlorophyll-*a*) were sampled, the biota sampled were epiphytical periphyton, phytoplankton and benthic macroinvertebrates. All data were subjected to multivariate and univariate regression analyses to identify correlations and patterns between the physico-chemical factors and the various components of the biota in relation to seasonality and hydrological phases.

The findings showed complex interactions between the physico-chemical and environmental factors in this highly specific aquatic ecosystem, with periphitic chlorophyll-*a* particularly significant. Epilithical periphyton proved useful as a biomonitoring tool, but due to the complex nature of the ecosystems involved, it would be used to greater advantage as a complementary tool to the current suite of indices.

48-O Evaluating outcomes of restorative biomanipulation management on a hypertrophic South Africa river reservoir through long-term cross-system comparison of remotely sensed trophic status monitoring data.   *Hart Rob* [1] - *Mark Matthews* [2]

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Escalating eutrophication severely threatens ecosystem and human health and welfare in the water-scarce South Africa, up to 75% of whose impounded inland waters are rated eutrophic or worse. With management crucial to minimize its adverse impacts, a food-web restructuring (biomanipulation) project on the hypertrophic Hartbeespoort Dam (HBPD) was initiated as a restorative in-lake measure in February 2008. We evaluate the outcome of this trial venture through temporal analysis of archival ± 4-day interval MERIS satellite data. Integrated whole-lake monthly average values of

chlorophyll (CHLORO - µg/l), cyanophyte content (CYANO - % of CHLORO), and cyanophyte cover (CYCOV - % lake area) were extracted for seven reservoirs – the experimental test system (HBPD), 3 adjacent 'catchment control' (CC) systems within the same drainage basin, and 3 'regional control' (RC) systems at HBPD's latitude – to compare temporal trends and corresponding anomaly profiles of these variables over 114 months (2002 to 2012).

Plankton was clearly seasonal in all systems, generally with summer highs and winter lows. Overall average values for CHLORO were 180 in HBPD, 91, 95 and 197 in the CC's, and 20, 74 and 151 in the RC's. Corresponding CYANO levels were 45 in HBPD, 9, 15 and 30 in the CC's, and 0.3 to 0.8 in the RC's. CYCOV averaged 51% in HBPD, 14, 16 and 33 in the CC's, and < 1 in all RC's. Overall average values of CHLORO (174 vs 187), CYANO (44.9 vs 45.2) and CYCOV (50.2 vs 51.7) showed no improvement after treatment started in HBPD (n = 62 vs 50), although ecosystem responses may be delayed by hysteresis. Linear time series analysis of monthly values and anomaly profiles (to remove/adjust for seasonal periodicity) showed directionally inconsistent trends. No significant ($p \leq 0.05$) changes in absolute values or anomalies were evident for HBPD, but occurred in CC's (5+5) and RC's (6+7). Absolute values of all parameters variously increased or declined, translating into both positive (in 1CC and 1RC) and negative (2 other RC's) anomaly profiles for CHLORO, CYANO and CYCOV (both with 1CC+1RC vs 1CC+1RC).

These contradictory trends suggest a lack of systematic drivers of change at the spatial (catchment or regional) and temporal scales investigated. Lack of improvement in HBPD since 2008 is thus attributable to ineffectiveness of the intervention measures rather than confounding environmental factors. Despite possible hysteresis delays, these 'test case' results challenge the utility of food-web restructuring as an effective counter-measure for eutrophic South African reservoirs. In this, they accord with and add to other lines of published evidence (analyses of zooplankton composition and abundance, of planktonic predator-prey biomass ratios, and of stable isotope studies of food-web structure) from various other SA reservoirs that negate prospects for successful biomanipulation, and mandate preventative rather than restorative management interventions.

48-O   The impact of the Benin city storm-water project on the water quality and zooplankton of Ogba River, Benin city, Nigeria.   *Michael Omoigberale [1] - Edewor Unuafe [1]*

University of Benin, Benin, Nigeria [1]

The Benin City Storm water Project, an initiative of the Edo State Government is aimed at alleviating the danger and discomfort of flooding in the Benin metropolis, providing drainage and managing flood risks, avoiding damage caused by erosion, controlling runoff and discharges, protecting the environment by preventing pollution and retaining natural systems, supporting sustainable development and respecting heritage by channeling the floodwater into the Ogba and Ikpoba Rivers in Benin City. This study was conducted to assess the impact of the Benin City storm-water project on the water quality and zooplankton of Ogba River, Benin City, Nigeria. Water quality and zooplankton were determined using standard methods at 4 study stations between August, 2014 and January, 2015. Water quality standards were used to assess the water quality. All physico-chemical parameters showed significant variation ($P<0.05$) across the study stations except air and water temperatures, flow rate, Hydrogen ion concentration (pH), dissolved oxygen (DO), chloride (Cl^-), phosphate (PO_4^{2-}), ammonium nitrogen (NH_4N), nitrate (NO_3^-) and sulphate (SO_4^{2-}). The water quality parameters were within the Federal Ministry of Environment (FMEnv) and World Health Organization (WHO) standards for surface water except DO which was below permissible limit, while elevated levels of biological oxygen demand (BOD) and chemical oxygen demand (COD) were recorded. Eight zooplankton species comprising four copepods, three cladocerans and one rotifer were encountered, with copepod being the dominant taxa. Diversity indices revealed that the highest and lowest values were recorded at stations 1 and 3 respectively. Zooplankton exhibited a significant positive correlation with the following parameters; turbidity, total suspended solid (TSS), total dissolved solids (TDS), COD, bicarbonates (HCO_3), potassium (K), NH_4N and NO_3^-. The study showed that the inflow of storm waters has invariably affected the water quality and the abundance and diversity of zooplankton in the Ogba River.

48-O   Importance of water column stability for the distribution of nutrients in the upper mixed layer in Lake Tanganyika.   *Prisca Shadrack Mziray [1], Ismael Aron Kimirei [1], Charles Lugomela [2], Peter Anton Stæhr[3], Dennis Trolle [3], Catherine O'Reilly [4], Huruma Fredrick Mgana [1]*

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Lake Tanganyika is permanently stratified and availability of nutrients in the productive layer depends largely on wind-driven mixing events. Inputs of nutrient from deeper layers into the photic zone are expected to have diminished over the last three decades due to generally lower winds which has reduced the depth and frequency of mixing events. A decline in mixing events is related to climate warming in the lake which is hypothesized to intensify the thermocline stability. This study aimed at studying the spatio-temporal distribution of nutrients and factors governing this process in the lake. Monthly discrete water samples were collected from the Kigoma Bay and Mahale for one year. The water samples were collected at an interval of 20 m from surface (0 m) to 100 m and 10 m from 100 to 200 m at both sites. These samples then were used to determine nutrient concentrations. Also Exo YSI (Yellow Springs Instrument) multisonde profiles for the 0-100 m column and discrete records of water temperature, pH, dissolved oxygen, and conductivity for the 110 -200 m were sampled. Nitrate-nitrogen (NO_3-N), nitrite-nitrogen (NO_2-N), ammonia-nitrogen (NH_4-N), total nitrogen (TN), soluble reactive phosphorus (SRP), and total phosphorus (TP) were analyzed spectrophotometrically following procedures described by APHA. Nutrient concentrations in the upper mixed layer were higher during the dry season than the wet season; and at Mahale than in Kigoma. Warming of the surface waters and reduced winds have enhanced water column stability, reducing mixing, causing a significant decrease in internal supply of nutrients into the upper mixed productive layer during the warmer and less windy wet/rainy season. The potential energy anomaly was higher during the wet season, which follows the long-term trend in the warming of the surface waters of Lake Tanganyika. We propose a concerted effort to monitor and make observation using high frequency monitoring equipment so as to detect even small change in the lake's water temperature and stability.

48-O Fish community dynamics in small riverine ecosystems of the Lake Victoria basin, Kenya and Uganda. *Benson M. Mwangi*

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Tropical freshwater ecosystems support large nimbers of endemic fish species. Lake Victoria, for example, harbors more than 300 endemic fish species. Riverine ecosystems around the lake contribute immensely to the lakes' fish species richness by providing breeding grounds for many of the lacustrine fish species. Many of these riverine ecosystems, however, are serious degraded with serious impacts on the fish community dynamics. A survey on the fish species composition in Rivers Kisian and Awach Seme (Kenya) and River Nambale (Uganda) revealed the fish community to be strikingly similar, constituting 11 species, dominated by *Clarias gariepinus* Burchell, *Barbus altianalis* Boulenger and *Barbus nyanzae* Whitehead. Other fish species included *Labeo victorianus* Boulenger, *Barbus cercops* Whitehead, *Barbus kerstenii* Peters, *Barbus jacksonii* Günther, *Barbus appleurograma, Oreochromis leucostictus* Trewavas, *Gambusia affinis* Baird & Girard, and *Bagrus docmak* Forsskål. Abundance and diversity of the fish species however varied significantly between and within the rivers. *B. altianalis* and *B. nyanzae* have been reported to be missing in Lake Victoria despite their occurrence in high abundance in the small rivers. These results suggest that the small rivers around the Lake Victoria basin can be important fish reservoirs for the lake hence the need for a riverine management within the basin.

48-P Vertical gradients in primary production in Lake Tanganyika.   *Ismael Aaron Kimirei [1] - Prisca Mziray [2] - Huruma F. Mgana [2] - Dennis Trolle [3] - Catherine M O'Reilly [4] - Peter Anton Staehr [3] - Charles Lugomela [2]*

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Lake Tanganyika is an oligotrophic deep central African lake which only mixes partially in the upper waters or at upwelling sites located in the inshore regions. Thermal stratification weakens during the cool, dry and windy season, allowing intrusions of deep nutrient rich waters into the photic zone. This is believed to be the main driver of seasonal

enhanced primary productivity which drives the important fish production in the lake. Fish is an essential source of animal protein and income to the entire region. Here we present new data on vertical gradients in pelagic primary production measured monthly from two northern sites (Kigoma Bay and Mahale) collected at an interval of 20m from surface (0m) to 100m for a year. We determined nutrient concentrations and measured primary production with the Pulsed Amplified Modulation (PAM) technique. Also continuous profiles of temperature, pH, dissolved oxygen, chlorophyll a (Chl) and conductivity were measured for the 0-100 m column using a multisonde. During the dry season elevated nutrient concentrations coincided with higher Chl concentrations and higher rates of primary production. In comparison the wet season had warmer surface waters, a more stable water column and lower nutrient and Chl and reduced primary production. The poster will show seasonal changes in vertical profiles of primary production and compare these with gradients in water chemistry and mixing conditions. Implications of regional changes in warming and wind conditions will be discussed.

48-P   The small eukaryotes of great tropical african lakes: the importance in the food web.   *Paulina Fermani* [1] - *Cédric Morana* [2] - *Marc Llirós* [3] - *Jean Pierre Descy* [3] - *Hugo Sarmento* [4]

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Microorganisms play a fundamental role in all biogeochemical cycles and constitute an important part of the structure of microbial food web in lakes and oceans. Small eukaryotes could be of even greater significance in oligotrophic tropical lakes, where environmental conditions constantly supports the smaller fraction of the plankton. The large East African Rift lakes have a high productivity. During the last decades active fisheries supply local populations, changing the structure of the food chain. Despite heterotrophic microorganisms are important in the biochemical cycles, they have been less explored. The aim of this work was to determinate the total abundance and biomass of planktonic protists over vertical profiles of four African lakes and to identify the importance in the food web. Samples was collected during the wet period in the pelagic zone of Victoria, Edward, and Albert in May 2012; and at two stations (Gisenyi and Ishungu) in Kivu, in February 2013. Limnological and biological samples was collected by members of the EAGLES, MICKI and DAMAS teams. Most of physical and chemical variables differed significantly ($p<0.001$) amongst lakes and the major difference was observed in Kivu. Low nutrients and Chlorophyll-*a* levels were found and they switched with depth. Autotrophic Eukaryotes (AEuk) also differed significantly ($p<0.05$) amongst lakes and the abundances and biomass were similar to other similar systems. The high values (2500 ind/ml) was found in the surface of Lake Victoria. The physical-chemical parameters and AEuk were highly correlated in most lakes, suggesting that they could be regulated by a bottom-up control. Picoplankton community was dominated by heterotrophic bacteria (mean: $2.9x10^6$ ind/ml) and a large amount of *Synechococus* (mean:$3.4x10^5$ ind/ml) which also were regulated by abiotics parameters. Heteroptrophic flagellates (HF) abundances, biovolumen and biomass profile differed according each lake and the numbers were typical of oligotrophic systems. Ishungu presented a peak of abundances (1534 ind/ml) and biomass (17.5 µgC/L) in 35 meters when nutrients begins to increase. In all lakes, the HF<5 µm were the most abundant organisms and they contributed with more than 60% the total density. This fraction of HF presented a significant differences between lakes ($p<0.01$). On the other hand, large cells (>10 µm) were almost undetectable and represented only 1 % of total HF abundance. Although we found large amounts of picoplankton, the assumption of great HF numbers were not observed. The low abundances of protist and the lack of a great correlation with the others microorganism suggest that in this lakes it would be more regulated by a top-down control by metazoplankton; and probably less energy reaches higher levels. This preliminary results will contribute to the overall understanding of the processes regulating the productivity of greats tropical lakes, in the context of the exploitation of its resources.

48-P Towards an integrated lake basin management plan for Lake Manyara, Tanzania, using a tiered multistakeholder approach. *Luc Brendonck [1], Luc Janssens de Bisthoven [2], Revocatus Machunda [3], Linus Munishi [3], Maarten Wynants [4]- An Steensels [4], Maryke Malan-Meerkotter [5], Tamuka Nhiwatiwa [6], Maarten Vanhove [2], Hans Komakech [3]*

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The sub-basin of the rift valley Lake Manyara (LM), Tanzania, a hotspot for biodiversity, offers important food sources, while as a national park it generates tourist revenues, contributing to poverty alleviation. The shores of the saline lake host a large town (Mto Wa Mbu), a ground water forest, small-holder and extensive irrigation agriculture, grazing grounds for pastoralists (mainly Maasai), wildlife corridors, and a number of lodges and tented camps. The multiple use of ecosystem services causes conflicts. The LM sub-basin is threatened, not the least by (1) declining water level due to water capture by agriculture and possibly climate change and (2) sedimentation of the basin due to erosion in the incoming rivers. Other threats to its biodiversity include pollution by agricultural pesticides, poaching, human encroachment, and illegal fisheries. Nowadays the LM sub-basin has no comprehensive integrated management plan, despite several past attempts, the awareness of local authorities and alarming data. For developing a Decision Support System (DSS) supporting an Integrated Lake Basin Management Plan (ILBMP), environmental flows and interactions with socio-economics, ecosystem services, biodiversity and climate change should be better understood and quantified. Therefore, a multidisciplinary team of biologists and (eco)hydrologists from Belgium (KU Leuven, RBINS-CEBioS), South Africa (UWC), Zimbabwe (UNZI), and Tanzania (NM-AIST) met local stakeholders for an interactive exchange/scoping of information. The stakeholders were representatives from farmers, pastoralists, policy makers at the level of the national park, the district and the sub-basin, as well as a Belgian NGO (Trias). A participative iteration was followed with (1) a stakeholders' analysis, listing their interest and influence in the process, (2) community mapping, drawing maps of the area from the own perspective, reporting and discussing it, (3) constructing a problem tree with possible reasons for the drying up of the lake and consequences for development and biodiversity and (4) establishing strengths, weaknesses, opportunities and threats in this process of developing a DSS. Next, a simple survey amongst the main beneficiaries of the lake shores will be carried out to explore more in detail some hypotheses arisen from this participative exercise, e.g. spatial and priority perceptions of resources and conflicts and reference topography. This will be combined with quantification of ground water and sediment flows as well as identification of key indicators of environmental change of the lake. All these elements will contribute to a holistic view which can feed an efficient DSS, in support of the implementation of a functioning ILBMP for the long term benefit of the Lake Manyara region. The Flemish Interuniversity cooperation for development (VLIR-UOS) is acknowledged for financial support within its North South South Programme.

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