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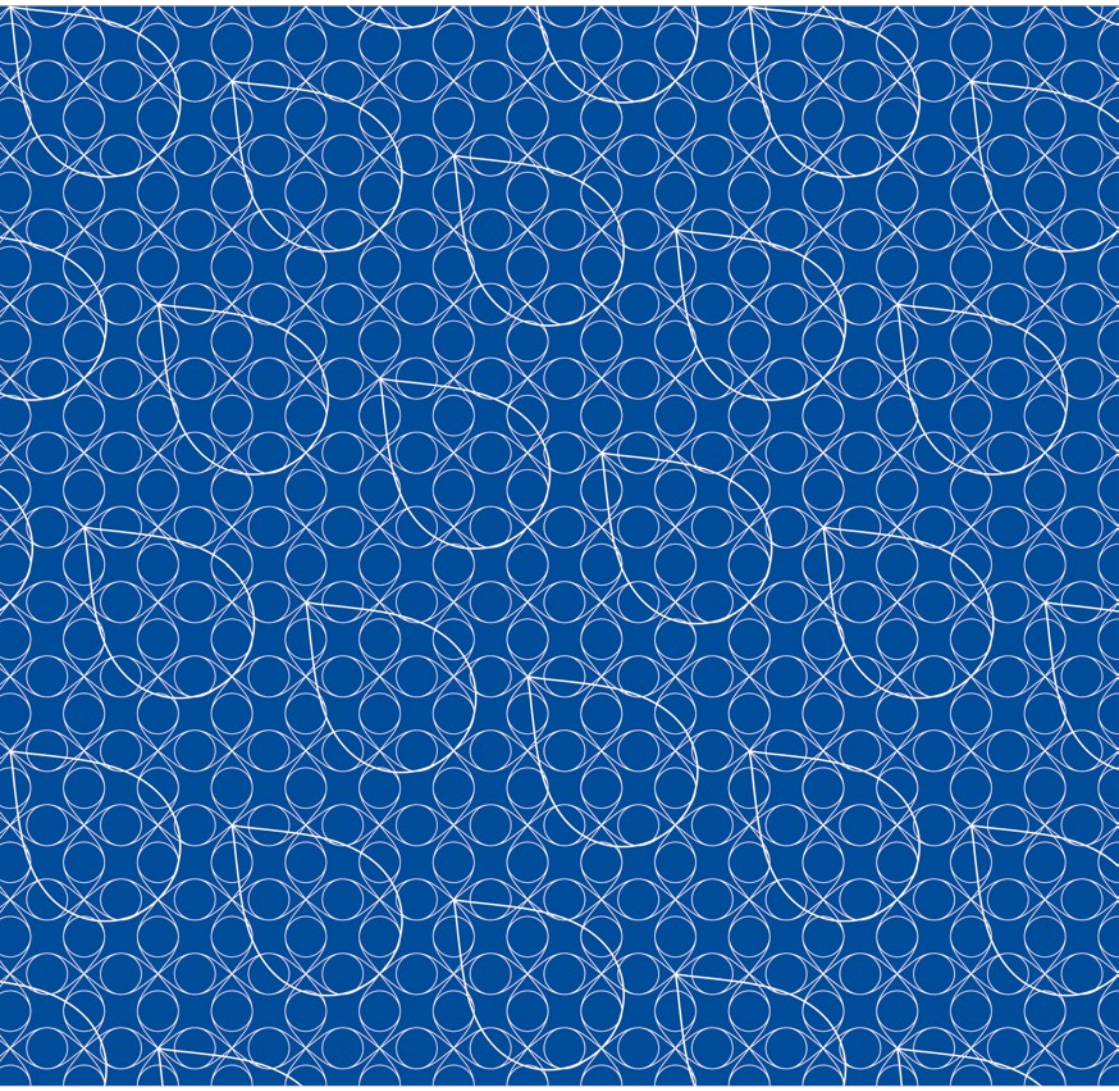

10 SYMPOSIUM FOR EUROPEAN FRESHWATER SCIENCES 2017

ABSTRACT BOOK

Keynote – Presentation

IMPLICATIONS OF GLOBAL CHANGE FOR AQUATIC COMMUNITIES: DO MICRO-EVOLUTIONARY SHIFTS IN POPULATION FUNCTIONAL TRAITS MAKE A DIFFERENCE?

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By most ecologists, species are considered as entities with fixed traits because rates of evolutionary adaptations are believed to be much slower than the rate of ecological dynamics. However, it is only in the latest years that an increasing number of ecologists come to realize that microevolutionary adaptation can take place at ecological time scales. Although microevolutionary trait shifts may seem small and insignificant in magnitude compared to the large trait changes that are documented for macro-evolutionary time scales, they may still be of considerable importance from an ecological perspective, as they may strongly determine the performance of contemporary populations and their interactions with the biotic and abiotic environment. This is especially relevant in the context of current global change, with anthropogenic impacts that cause the biotic and abiotic environment of organisms to change at unprecedented rates. In this talk, I will introduce the concept of eco-evolutionary dynamics, illustrate its relevance for aquatic systems with a variety of examples and try to address the question whether such dynamics may effectively contribute to a better understanding of the response of aquatic biota to anthropogenic pressures.

SERENDIPIDY IN SCIENCE – 35 YEARS STUDYING A TROPICAL LAKE

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Lake Naivasha, Kenya, was once a rather unusual lake, but is becoming ordinary as it fills with alien species that are now commonplace and it becomes surrounded by developments and settlements. This presentation looks at 50 years of change in the lake through the 35 years we have been studying it and whether the knowledge of its limnology acquired, is any use in its management. A small (100-140km2) freshwater lake in a chain of mostly saline-alkaline lakes running along the predominantly arid Eastern Rift Valley floor between Ethiopia and Tanzania, Naivasha has always been essential to human existence and, since colonization in the lake 19th Century, drawn settlement. People had little impact on its ecology before the middle of the 20th Century, but an increasing list of deliberate introductions and accidental arrivals of alien species, that is still continuing, mean that the lake ecosystem is wholly novel beneath the water, yet can appear little changed above. In parallel to the alien invasion, agricultural and horticultural developments, bringing several hundred thousand people in new settlements, have markedly changed the lake hinterland and threatened its water quality. Intense subsistence cultivation throughout the catchment with increasing population reduce the quality and quantity of incoming river waters. Against these threats to its ecology, the lake responds with the most fickle hydrology imaginable, as a consequence of the Inter Tropical Convergence Zone. Seemingly about to become a dustbowl in 2009 through over-abstraction on top of a natural drought, that brought international experts to help write yet more management plans, the lake responded in heavy rains by rising by 2012 to a level last seen in 1969, with native species and high water quality returning. With such un-predictability and a near-impossibility of modeling, how useful is its science? Naivasha has been a great training ground for students and foreign scientists as a first 'taste' of Africa, but none of the science has generated any effective monitoring at all to guide sustainable management. Will this change? I shall give you a mentally easy presentation, to help you wake up, on the morning after the conference dinner.

MICROBIAL NITRIFICATION IN URBAN STREAMS: FROM SINGLE CELL ACTIVITY TO ECOSYSTEM PROCESSES

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Ammonia oxidization is the first and rate-limiting step of nitrification, which connects ecosystems' nitrogen (N) inputs (fixation, mineralization) with losses (denitrification, anamox). Ammonia oxidization is carried out by both ammonia oxidizing archaea (AOA) and bacteria (AOB). Although sharing a common function, AOA and AOB are phylogenetically distinct, suggesting different ecological adaptations and phenotypic characteristics. In high N loaded ecosystems, such as urban streams receiving effluents from wastewater treatment plants (WWTP), ammonia oxidization is highly relevant, and microbial biofilms growing on submerged substrata carry out a fundamental role. Despite the pivotal effect of high N concentrations in triggering eutrophication of downstream waters, there are only few mechanistic insights on how ammonia oxidation is controlled in human altered streams. In my PhD thesis, I aimed to unveil regulating factors and driving mechanisms of ammonia oxidation from single cell to community and ecosystem scales through the combination of a large variety of molecular and biogeochemical tools in both field and laboratory experiments. In my presentation, I will show how the effluent of WWTPs shapes the distribution, community composition and activity of AOA and AOB and how this shift is reflected in differential nitrification rates at ecosystem scale. Moreover, I will unveil differential photosensitivity of ammonia oxidizing organisms as an important driver for niche separation; and how habitat heterogeneity within stream reaches influences the spatial distribution of ammonia oxidizers at whole-reach scale. Finally, I will evaluate the relative contribution of different microbial communities (epilithic and epipsammic biofilms) to whole-reach nitrification.

NEW PERSPECTIVES IN THE STUDY OF LAKE FOOD WEBS

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In this current era of unprecedented global environmental change, studying lakes from a system-wide perspective provides a holistic basis for understanding and conserving lake ecosystems. In this talk, I'll highlight several insights into our understanding of lakes that derive from adopting a food web perspective. First, benthic primary production can be an important contributor to whole-lake primary production, and seems to make a disproportionately large contribution to higher trophic levels. Second, lakes are linked to the surrounding landscape through aquatic insect emergence events. Studies from Lake Myvatn, Iceland have provided a basis for better understanding the role of lake-to-land food web linkages. Finally, compound-specific stable isotope studies are providing new insights into long term food web change and historical niche partitioning in fish communities. Food web studies as discussed here are part of a larger movement to apply more holistic and system-wide approaches to the study of lakes.

A STUDY OF THE POTENTIAL IMPACTS OF CLIMATE CHANGE ON OYSTER PRODUCTION IN WHIN ESTUARY IN GHANA

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Ghana depends heavily on her coastal resources for food, income and employment with the Whin Estuary being no exception. It is feared that this ecosystem could be lost in the event of Climate Change (CC) because of its close tie to the sea. This could be magnified by land use activities due to potential impact on food security, livelihood and water. Using case scenarios, historic mollusc catch and current catch data of West African Oyster (Crassostrea tulipa) and environmental factors were used as surrogates of the ecological status and sustainability of oyster fishery. Triangulation approach involving the use of focus group discussions, key informant interview, field measurements and observations were employed to solicit data on catch, land use activities and perception of oyster harvesters on the fishery. A general linear model was performed to determine the influence of environmental variables on oyster abundance and spatial distribution. Ranking of identified land use stressors were done using the (Battisti et al., 2009) Salafsky et al. (2003) ranking method. The results of the study showed that mollusc catch decline with increase temperatures and increase in volume of rainfall. Among the non climatic stressors in the area, the presence of sewage outlets were the major threat (8), followed by uncontrolled mangrove cutting (7), sand winning (6) and the least of the threats were refuse damps(4) and farming activities (3). There was no significant differences in the magnitude of threats of refuse dumps and farming activities.

Keywords: Abundance, Catch, Ecological, Oyster, Threats

IMPACTS OF CLIMATE CHANGE ON FOOD WEBS: ROLE OF INDIVIDUAL PHENOTYPIC PLASTICITY AND NON-TROPHIC INTERACTIONS

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Understanding the dependence of species interaction strengths on environmental factors, species traits and species diversity is crucial to predict community dynamics and persistence in a rapidly changing world. Using a cladoceran–dragonfly system, we experimentally investigated the effects of thermal acclimation, acute temperature change and enrichment on predator functional response and metabolic rate and calculated their consequences on trophic interaction strength and food-chain stability. We also measured the effects of predator diversity, prey density, and temperature on trophic and non-trophic interaction strengths within a freshwater food web.

We found that (1) thermal acclimation of predators can buffer negative impacts of environmental change on predators and increase food-web stability and persistence, (2) species interaction strengths (i.e. the combined result of trophic and non-trophic interactions) cannot be predicted from trophic interactions alone and (3) temperature and prey density affect strengths of both interaction types, sometimes in opposite directions. We conclude that the effects of acclimation and non-trophic interactions should not be overlooked if we aim to understand the effects of climate change on species interaction strength and food-web stability.

STRUCTURAL AND FUNCTIONAL RESPONSES OF INVERTEBRATE COMMUNITIES TO CLIMATE CHANGE AND THEIR INTERACTIONS WITH FLOW REGULATION IN ALPINE RIVERS

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Understanding how communities respond to climate change is critical for assessing biodiversity vulnerability and guiding conservation efforts. Predicting these responses has thus become a central goal in ecology. Freshwater ecosystems are experiencing biodiversity declines far greater than terrestrial and marine ecosystems. Within these systems, while there is a multitude of recent studies which examined the taxonomical responses of communities to climate change in rivers, the use of functional trait-based approaches are still scarce. Furthermore, very few studies have focused on Alpine systems, one of the most sensitive areas to climate change which are also considered as sentinel systems of climate change and could provide early warning of wider-scale changes. In addition, many Alpine river systems are impacted by hydropower infrastructures. Yet, there is a minimal understanding of how dams alter biological communities in a context of climate change. Thus, synergistic or antagonistic effects could be found between climate change and flow regulation. The current work tries to shed light on this issue disentangling the effect of climate change on regulated and free-flowing alpine rivers from different perspectives. Here, we present preliminary results of the structural, compositional and functional responses of stream invertebrate communities to climate change in two Alpine rivers from South-eastern France, by comparing data collected in the 70's and 2010's. One of them is influenced by hydropower production while the other one is still in rather pristine conditions, which allowed us to explore the interacting effects of climate change with human-induced flow alterations on Alpine communities.

ACCUMULATIVE IMPACT OF MULTIPLE GLOBAL-CHANGE STRESSORS MODULATES THE PHYTOPLANKTON-BACTERIA INTERACTION

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Aquatic ecosystems worldwide are undergoing unpredictable perturbations linked to global change which include increases in the nutrient concentrations, higher surface temperatures (T) and acidification (CO2), and higher radiation (UVR) levels by the shallowing of the upper mixed layers. The impacts of these factors on the phytoplankton-bacteria relationship is still under debate due to the scarcity of studies assessing multi-stressor effects on this interaction although it is the main relationship to connecting microbial loop and grazing food web. Thus, our aim was to test whether future global change conditions could generate a mismatch in the phytoplankton-bacteria coupling by an unbalance between the bacterial carbon demands (BCD) and supplies of organic carbon by phytoplankton excretion (EOC). A survey of recent reports from our research group shows that the interaction among different stressors (UVR, nutrients inputs, CO2, vertical mixing) generated substantial changes in the ability of EOC to satisfy BCD with respect to the effect of each single factor. Our results indicates that the above four-level interactions among these abiotic stressors modify the commensalistic phytoplankton-bacteria relationship with implications in ecosystem functioning.

GLACIER RETREAT EFFECTS ON MOUNTAIN STREAM ECOSYSTEMS

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Glacier-fed streams display very specific flow regime characterized by a strong temporal variability at various temporal scales due to the complexity of the water storages and releases by glaciers. However, the acceleration of glacier shrinkage under the ongoing climate change results in a strong alteration of glacier runoff. In particular, we expect an increase in both low and high extreme flow events. In a tropical glacierized catchment, we examine the relationship between flow fluctuation and aquatic community composition from the diurnal to the inter-annual time scales to identify the mechanisms driving the community structure and predict the aquatic biodiversity response to potential changes in flow regime under global warming. Based on observational and experimental studies, we show that the benthic fauna is highly adapted to the natural flow fluctuation and display both resistance and resilience to high and low flow events. However, our studies suggest that an increase in frequency of those extreme flow events might prevent communities to fully recover leading to irreversible shifts; and that reduction in glacier runoff would strongly affect the remarkable mountain stream biodiversity.

A GLIMPSE INTO THE FUTURE: CYANOBACTERIA EXPECTED TO THRIVE IN A LARGE SHALLOW LAKE UNDER MULTIPLE STRESS

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Regional climate-related variables (precipitation, air temperature) and a lake's main tributary hydrological indicators (river flow, dissolved inorganic carbon) were employed into a model chain for predicting the evolution of cyanobacteria and zooplankton (rotifer) biomass in that lake for the 2030-2060 period. Simulations were based on the future climate predicted under both the Representative Concentration Pathways 4.5 and 8.5 scenarios which, combined with three realistic policy-making and basin land-use evolution lead to six scenarios for future water quality. Model results showed that mean annual river flow is expected to decline between 3 to 20%, depending of the scenario. Concentration of river dissolved inorganic carbon is predicted to follow the opposite trend and might soar up to twice the 2005-2014 average concentration. Lake planktonic primary producers will display quantitative changes in the future decades whereas zooplankters will not. A 2 to 10% increase in mean cyanobacteria biomass is accompanied by a stagnation (-3 to +2%) of rotifer biomass. Changes in cyanobacteria and rotifer phenology are expected: a surge of cyanobacteria biomass in winter and a shortening of the rotifer biomass spring peak. The expected quantitative changes on the biota were magnified in those scenarios where forested area conversion to cropland and water abstraction were the greatest.

DOES EUTROPHICATION AFFECT THE RESPONSE OF STREAM INVERTEBRATE COMMUNITIES TO EXTREME FLOOD EVENTS?

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An increase in frequency of extreme flood events is now emerging as a threat to aquatic ecosystems. Many watersheds have been also adversely affected by nutrient pollution; however, it is still unclear how nutrient enrichment may alter the effects of extreme floods on stream invertebrate communities. We studied a 1-in-50 year flood in Wellington, New Zealand in 2015 at five stream sites which were affected the most by the flood's magnitude. PCA of pre-flood six nutrient measures, which were collected from 2004 to 2015, divided the five sites into three groups: low (two sites), medium (one site) and high nutrient levels (two sites). The 13-year data showed that the large flood had different effects in different enrichment groups on: periphyton biomass, diversity indices, and community composition. The flood significantly reduced periphyton biomass in the high enrichment group. Diversity indices (Simpson index and Species richness) were significantly reduced post-flood at sites in the low enrichment group; however, multivariate analysis showed that the large flood only affected communities in the high enrichment group. Nutrient
enrichment seems to result in communities more sensitive to floods.

CLIMATIC CONTROLS ON THE TRANSFORMATION OF DISSOLVED ORGANIC MATTER IN A SUBALPINE LAKE

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In-lake processes such as microbial degradation, photochemical oxidation, and autotrophic production can strongly modify DOM concentrations and its biogeochemical composition. This potential role of lakes as sites of enhanced DOM reactivity has been explored conceptually. However, to date experimental evidence remains scarce and fragmentary. Here, we present a multi-seasonal assessment of the capacity of an oligotrophic, pre-Alpine lake to transform DOM; and we unveil how this capacity changes over time as a function of hydrology and water temperature. We measured DOM quantity and its fluorescence properties at the inflow and outflow of Lake Lunz (Austria) at a 2-day frequency during two years (2015-2016). These two years had a similar annual variation of water temperature; however, they had highly contrasting hydrological regimes: 2015 had a very dry summer, whereas in 2016 rainfall events occurred continuously throughout the year.

Our results showed that during the dry year, the intensity of DOM transformation strongly co-varied with water temperature: it followed a gradual oscillation from minimal transformation in winter to maximal in summer. During maximal transformation, the terrestrial and humic-like character of inflowing DOM shifted to an autotrophically-derived protein-like fluorescence signature. Therefore, water temperature appeared as the main driver of the capacity of the lake to transform DOM. However, during the wet year this oscillation did not occur, and the outflowing DOM remained stable throughout the year. These results reveal that a high frequency of storm events can override the effects of temperature and inhibit the capacity of the lake to transform DOM.

CLIMATE WARMING AND FRESHWATER ZOOPLANKTON: A DECREASE OF FOOD QUALITY FOR FISH?

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To evaluate a potential effect of global climate change on zooplankton nutritive value we sampled 5 cold and 8 warm lakes in Europe and Asia. The nutritive value was estimated using contents of omega-3 polyunsaturated fatty acids (PUFA), namely eicosapentaenoic acid (20:5n-3, EPA) and docosahexaenoic acid (22:6n-3, DHA), conditionally essential for fish growth and development. We compared two main taxonomic groups of freshwater zooplankton, Cladocera and Copepoda, since the climate change was proven to effect proportions of these two taxa. Contents of EPA per organic carbon unit in biomass of Cladocera and Copepoda overlapped, while contents of DHA in Copepoda were significantly higher in Copepoda. The above differences between taxa were invariant with water temperature and likely were caused by phylogenetic factors, rather than any homeoviscous adaptation of individuals. Thus, if the proportion of Copepoda in freshwater zooplankton decrease with the climatic increase of water temperature, the nutritive quality of zooplankton for fish, regarding DHA content, will be diminished.

WARMING REINFORCES EUTROPHICATION SYMPTOMS IN A DEEP ALPINE LAKE

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We investigated effects of seasonal air temperature on ecosystem response of the north basin of Lake Lugano (Switzerland and Italy), a deep Alpine lake recovering from eutrophication. A priori ideas concerning the effects of seasonal temperature on key ecosystem responses were formalized in a conceptual model (path diagram), which was tested against observed responses (from 28 years of monitoring data) using structural equation modelling (SEM). Results broadly supported our SEM model indicating that seasonal air temperature pervasively affects ecosystem response within the north basin of Lake Lugano. Warmer-than-usual winters restricted depth of vertical mixing during lake turnover, reducing replenishment of phosphorus (P) to surface waters. Although P reduction increased the potential for nutrient limitation, warmer winters and summers led to increases in summer phytoplankton biomass through complex direct and indirect food-web effects. This paradoxical effect on phytoplankton suggests that climate warming might impede lake recovery from eutrophication, and likely increase required management intervention to meet restoration targets.

LONG-TIME TREND ANALYSES OF FISH ASSEMBLAGES IN LARGE FRENCH RIVERS

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Global changes are increasingly affecting freshwater ecosystems resulting in strong modifications in the structure and functioning of aquatic assemblages over a relatively small period of time. A better understanding of observed ecological trends is needed to anticipate and forecast future ecosystem changes. For this purpose, data from the annual electrofishing campaigns conducted as part of the hydro-ecological monitoring of the French nuclear power plants were assembled. This unique dataset is made up of 30 long-term time series on the fish assemblages of the major French rivers over the last 20 to 40 years. We conducted meta-analyses of trend statistics derived from these 30 biological time series to investigate the impact of global changes on the structure and functional characteristics of fish assemblages. Shared changes among time series in assemblage compositions, diversity metrics, ecological traits and functional indices were tested. In addition, we examined the place of several recent extreme climatic events (four heat waves since 2003) within the whole time series looking for ecological tipping points. Finally, we updated the results of a similar study conducted 10 years ago to seek for recent shifts in long-term biological trends. This study highlights the most recent observed responses of aquatic communities to global changes.

RIVER ECOSYSTEMS UNDER THERMAL STRESS: ONGOING RESEARCH PROJECT OUTLOOK

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Heat waves coupled to water scarcity events alter biological communities and ecosystem processes in rivers and these events could become more frequent and intense in near future as a consequence of climate change and water use intensification. Delta temperatures of several Celsius degrees currently occur at the outlet of many water-cooling systems of factories and power plants, and may affect river processes locally. A better understanding of the functional consequences of this type of thermal stress could bring insights into future effects of climate change. With this 2-year research project (2017-2019), we seek to assess the influence of water warming on the river continuum, diversity of organisms and associated ecosystem services. For this purpose, experimental approaches will be conducted, ranging from the measurement of metabolisms under controlled conditions in relevant biological models (free-living nematodes, fishes) to the monitoring of community and ecosystem responses in situ (at the outlet of Golfech nuclear power plant, river Garonne, France). This project will also measure modifications of metabolism, ecological engineering behaviors, and topology of energy fluxes passing through complex communities (bacteria, algae, meiofauna, macrofauna, fishes) in response to water warming. We expect that this project will shed light on the ecological effects of water warming and support the efforts of the scientific community to better understand the multifaceted impact of climate change on river ecosystems.

THE SIERRA NEVADA LAKES: STUDY SYSTEMS FOR MULTIPLE STRESSORS OF RECENT ENVIRONMENTAL CHANGE IN SEMIARID ALPINE AREAS

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The Sierra Nevada is the southernmost mountain range in Europe and the summit area has a high mountain Mediterranean climate which is defined by a severe summer drought, receiving a considerable input of Saharan dust and a high UV radiation. In the Sierra Nevada there are more of 50 glacial origin lakes between 2800 and 3050 m a.s.l, all of them shallow, low alkalinity and productivity lakes above the tree line and cold polymictic and fishless lakes. Lake hydrological regime is diverse since some lakes may become dry while others may show a variable reduction of their water level which becomes higher and more long-lasting in warm and dry years than in cold and wet years.
Subfossil diatom and cladocera changes and fossil chlorophyll a were analyzed from surface sediment cores of 17 lakes in the Sierra Nevada and from short cores (~150 years) in six of these lakes. Chlorophyll-a production has increased since the 1970s, consistent with a response to rising air temperatures and the intensification of atmospheric deposition of Saharan phosphorus. Similar shifts in cladoceran and diatom taxa across lakes began over a century ago, but have intensified over the past ~50 years, concurrent with trends in regional air temperature, precipitation, and increased atmospheric Ca deposition. Factors affecting the modern biological assemblages are mainly related to the lake hydrological regime and morphometry. The predicted intensification of droughts for this Mediterranean area and Saharan dust deposition will further impact the ecological condition of these ecosystems.

IS THE BALKAN GOLDENRING AMONG THE LOSERS OR WINNERS OF CLIMATE CHANGE? THOUGHTS ON THE BASIS OF A SIX-YEAR LONG STUDY

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The Balkan Goldenring is a protected and red-listed charismatic species of hilly and mountainous headwaters in Central and South-eastern Europe and has a relatively small range. The species have its distribution centre in the Balkan and its area extends towards the eastern Alps and the Carpathians. In the last decade, (1) a faunistic survey was performed covering almost 100 sites in Hungary, (2) all new records were summarized from Central Europe, (3) larval microdistribution were explored in monthly intervals from June 2011 to May 2012 at eight streams in the Mecsek Mountains, SW Hungary and (4) exuviae were mapped and collected from May to August in 6-days intervals for six consecutive years (2011-2016) at one site, where 200-m long and 10-m wide sections were searched thoroughly for exuviae along both side of the stream. In 2012, a severe drought occurred between August and October. The emergence trends and timings were almost identical during the six sampling years, but the number of emerged individuals decreased heavily in the year after the drought (2013), however it was quickly restored to normal (2014), and even significantly increased (2015, 2016) compared to the former years. Summing up all the results from larval and exuvial samplings and newly found occurrences from Hungary, the Czech Republic, Slovakia, Italy, Romania and the Ukraine suggests that climate change may be an advantage for the species, which is recently expanding its area. The conference participation was supported by the Doctoral Student Association of University of Pécs.

LONG-TERM CHANGES IN BIOLOGICAL DIVERSITY OF RUNNING WATERS – THE RIVERCHANGE PROJECT

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A gradual increase in annual mean air temperature and changes in temporal distribution of precipitation was recorded in the Czech Republic during past decades. The response of aquatic organisms, which are usually considered as sensitive indicators of such change, is a subject of many studies and projects. The aim of the research project „Monitoring of long-term changes in biological diversity of running waters during climate change: design, realisation, and implementation in the ARROW public information system“ (acronym RIVERCHANGE) is to assess the influence of changes in temperature and precipitation on aquatic organisms inhabiting lentic waters (algae, macrophytes, invertebrates, fish) with respect to land-use and water quality temporal changes. The long-term biotic and abiotic data were collected and evaluated; and a publicly available web-based interactive tool for presentation of data and results has been developed as a part of Czech national monitoring information system ARROW (Assessment and Reference Reports of Water Monitoring).
This contribution presents results describing the gradual long-term changes in aquatic biodiversity and points out some relationships between biotic and abiotic components of aquatic environment with comments to the shifts in taxonomical and/or functional composition of selected taxocoenoses and distributional changes of selected taxa.
The research is supported by a grant EHP-CZ02-OV-1-018-2014 from Iceland, Liechtenstein and Norway.

ROTIFERS IN LAKE LUNZ, AUSTRIA – WHAT HAS CHANGED SINCE THE 1970-80S?

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Rotifers are very important, yet often neglected and understudied part of zooplankton communities. For standard lake samplings are commonly used plankton nets too coarse to capture quantitatively microzooplankton. This leads to underestimation of their densities and biomass, which can be as large as biomass of crustaceoplankton and have therefore higher impact in aquatic food webs than commonly considered. Moreover, since rotifers have been mostly ignored due to this sample bias in long time monitoring programs as well, only rarely is there an opportunity to study impacts of long time environmental shifts on rotifers, such as climate change.

In Lake Lunz, an oligotrophic montane lake in Lower Austria, were rotifers studied thoroughly in the 1970- 80s. Analysis of long time measurements of the lake temperature revealed that the mean surface temperature is continuously increasing since 1981, with very strong increase especially in April, May and June. Since spring 2016, sampling of microzooplankton has been included into the lake monitoring program. In this contribution will be presented changes of the rotifers community including diversity, abundance, biomass and vertical structure with respect to documented environmental changes and compared with the available data from 30-50 years ago.

EXPLORING CLIMATE CHANGE STRESSORS ON CHAROPHYTES: EFFECTS OF UV-RADIATION INTERACTING WITH NO3 CONCENTRATION AND TEMPERATURE

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Within the climate change context, the Mediterranean region is expected to be one of the most sensitive areas in the world. An increase in temperature accompanied by a decrease in precipitation will drive to a reduction in water level in shallow waterbodies, resulting in the concentration of nutrients in the water column and favouring higher amount of UV-radiation to penetrate into deeper layers, reaching macrophyte beds. Thereby, it is important to understand how these stressors could affect biotic processes in order to assess the impact of climate change over submerged vegetation structure, dynamics and functioning. Charophytes (submerged macrophytes) are considered as ecological engineers and key species in freshwater ecosystems. By means of two laboratory experiments, we tested whether an increase in UV-radiation accompanied by an increase in (i) temperature or (ii) nitrate concentration, could affect two species of cosmopolitan charophytes (Chara hispida and C. vulgaris) from two different origins. We focused on growth, morphology and metabolism. The UV-radiation had a negative effect in the four populations with relative growth rates, on average, 30% lower in those organisms receiving higher doses. However, this damage can be minimized by a concomitant increase in temperature which had a positive effect on growth (higher biomass, elongation and lateral ramification production). A two-fold increase in nitrate concentration had no significant effects. Due to the proven interaction of factors, focussing on macrophyte ecological responses to multiple, simultaneous stressors is highly recommended in order to develop realistic predictions on expected aquatic ecosystem shifts driven by climate change.

PHYSICAL LIMNOLOGICAL RESPONSE IN A MONOMICTIC UK LAKE TO A CHANGING CLIMATE AND WEATHER EXTREMES

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There has been much research exploring the impact of climate change on dimictic (seasonally ice covered) lake systems, yet little on the response in temperate, lowland monomictic systems. This study assesses the long term physical limnological change in a deep, eutrophic monomictic UK lake (Rostherne Mere) to understand the impact of a warming climate on the physical system, with special interest on the influence of the increasing number of climatic extreme events (e.g. heat waves and unseasonally high rainfall). A trend of rising air temperature (+0.7 ^{0}C) and precipitation (+62 mm) over the last 43-years has impacted the lake water column energy budget and thermal regime, with alterations in the timing of stratification onset and overturn. However, due to the dynamic response of lake systems to changes in the atmosphere, the short-term influence of weather extremes is also of great importance, and will continue to grow in importance with a continued increase in the frequency of extreme events as a consequence of climate change. These short-term perturbations in weather are disentangled from the long-term climatic trend to assess the impact on the physical limnology of such changes and applied to an extended historical sedimentary record at Rostherne Mere. We further explore the implications for lake functioning (physical, biogeochemical and ecological) for this and other similar lake systems under likely trajectories of climate change.

IS CLIMATE CHANGE INCREASING THE THREATS FROM HARMFUL ALGAL BLOOMS?

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Cyanobacteria blooms are becoming an ever increasing threat to global water security. What role climate change has in this threat, alone and in combination with eutrophication, needs to be better understood. In particular, there is concern that cyanobacteria blooms will increase with higher temperatures and that this response will be exacerbated by nutrient enrichment. Using data from 779 natural European lakes across broad environmental gradients we explored the response of cyanobacteria to the combined effects of anthropogenic stressors: nutrient enrichment, temperature and rainfall. We found that the sensitivity of cyanobacteria to combinations of stressors depends on environmental context, i.e. the characteristics of the lake, in particular depth, alkalinity and humic type but also the gradient of the nutrient stressor. We found the response to nutrient enrichment was exacerbated by elevated temperatures, however this interaction was not always prevalent across different lake types, was not consistently positive and also varied in the magnitude of the effect. In low nutrient lakes there was no effect of rainfall whilst rainfall dampened the response to nutrients in mesotrophic and hypertrophic lakes, although, as before, this response was not present across all lake types. These findings will be discussed alongside results from a mesocosm experiment which explored the response of cyanobacteria to the same stressor combinations and inferences will be drawn from these combined results about how water quality in lakes is likely to be affected by global change.

HOW DOES ECOSYSTEM STRUCTURE AND FUNCTION RESPOND TO LOW-FLOW CONDITIONS IN AGRICULTURAL STREAMS?

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Streams in Europe and other regions will experience more frequent and prolonged low-flow events due to climate change in the coming decades, especially in streams impacted by abstraction for drinking water, industry, and irrigation. Low-flow events can alter the physical and biological structure of the stream (e.g., sedimentation and species composition, respectively), which may affect ecosystem function (e.g., whole-stream metabolism, decomposition). To examine the effects of low flow and the associated stressors on stream function, we conducted both a manipulative field study, reducing baseflow discharge 85% in a headwater stream, and experiments in artificial stream channels. Our research demonstrated that the benthic resources shifted toward a higher proportion of fine particulate organic matter and less autotrophic biofilm, with cascading effects on higher trophic levels. Furthermore, nutrient retention decreased, which, when coupled with less autotrophic biomass, may enhance nutrient export and, in turn, downstream eutrophication during low-flow conditions.

APPROACHING THE COMBINED IMPACT OF CLIMATE CHANGE AND CHEMICAL STRESSORS ON RIVER BIOFILMS.

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Freshwater ecosystems are threatened by multiple stressors (i.e. physical, chemical and biological stressors) which add to those associated to climate change. While the impact of stressors as separate entities is reasonably understood, the combined impact of several stressors with different mode-of-action is less known, particularly regarding the potential interactions that may take place. Resolving the effects of multiple stressors in ecosystems is complicated by many external factors that increase variability within the responses. This may be partially solved by means of controlled laboratory experiments. The present work aims to detect the size and sign of interactions between co-occurring stressors on river biofilm communities. To that purpose, an experimental approach using microcosms was applied following a full-factorial design. Lab-grown biofilms were exposed to a set of chemical and physical stressors, and their combinations. Physical stressors included warming and desiccation, as representative of climate change-related stress. Chemical stressors included the herbicide diuron and the antibiotic erythromycin, as examples of agricultural and urban pollutants, respectively. Biofilms were exposed to these stressors for a short time (40h), and the response of a set of variables was investigated. These variables included structural and functional-level endpoints, as well as genetic biomarkers. The results were fitted using a General Linear Model (GLM) in order to show significant interactions. The GLM brought to light a non-negligible number of significant interactions. Physical stressors originated the strongest responses in terms of effect size and significantly interacted with chemicals, indicating the potential for climate change-related stressors to interact with chemical pollution.

EFFECT OF TEMPERATURE ON THE COMPOSITION AND DYNAMICS OF PERIPHYTON IN EXPERIMENTAL MICROCOSMS

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In the context of the global climate change, an important ecological issue concerns the changes in aquatic community structure under the effect of water warming. Particularly, there is a need to know how important primary producers such as microalgae will be affected by the current rise in temperature. The present work is an assessment of the effect of temperature on freshwater periphyton. It is based on a long-term microcosm experiment originally designed for the study of fish populations. The microcosms are continuously fed with filtered water from an adjacent stream and they are maintained at about 20 and 30°C. After several months of experiment, artificial substrates were placed at the two temperature levels and their colonization by periphyton was monitored using a benthic fluorimetric probe (bbe BenthoTorch). The composition and growth of periphyton were compared between the two temperature conditions. A striking result was a higher abundance of filamentous cyanobacteria in the warmer microcosms, although the same cyanobacteria proliferate in the neighbouring river at fall/winter seasons. The experiment under controlled conditions was useful to address the single effect of temperature on periphyton, while other factors influenced by climate change may also be important for the evolution of microalgal communities in aquatic ecosystems.

DIFFERENCES IN SEASONAL AND LOCAL IN-LAKE DOM BIODEGRADABILITY BY SUBALPINE FRESHWATER MICROORGANISMS – A BIOASSAY APPROACH

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Current climate change scenarios predict considerable hydrological variability in lake catchments that may have a direct bearing on carbon cycling in lakes. Dissolved organic matter (DOM) often constitutes the largest carbon pool in lakes and supplies energy-yielding substrates to microbes. The accessibility and biodegradability of DOM are key factors that eventually affect microbial carbon consumption and respiration in lakes. It is thus important to account for the spatio-seasonal variability in environmental factors (e.g. temperature and nutrients) and in community composition that affect the composition and degradability of DOM composition and biodegradability. Furthermore, interactions of specific aquatic DOM signatures and the microbial population still remain widely debated.
In this lake study we examined the seasonal and spatial variation of DOM biodegradability by monitoring chromophoric DOM quantity and quality, inorganic nutrients, CO2 and bacterial growth over 20 days in dark bioassays with water from the lake inflow, outflow and at three depths of an oligotrophic subalpine lake. Preliminary results reveal highest microbial abundance in metalimnetic water during winter and summer, and in the inflow during spring and autumn after 20 days. In general, the increase of bacterial abundance was highest in inflow water, suggesting effective utilisation of terrestrial DOM. Nonetheless, microbial biomass differed only marginally among all sites with the exception of autumn samples where outflow and metalimnion turn out most productive in the end of bioassays. These results suggest that increasing terrestrial primary production due to climate change may increase DOM degradability and thus bacterial growth.

BODY SIZE BUT NOT PREDATION RISK MODULATE LIFE HISTORY RESPONSES TO WARMING IN MAYFLY LARVAE

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Understanding the effects of temperature on individual life histories and species interactions is essential to predict the impact of the ongoing climate change on entire communities. Life histories of ectotherms are primarily driven by temperature. Moreover, many species respond strongly to predation risk, but the joint effects of temperature and predation risk are virtually unknown. We focused on life history responses of the larvae of mayfly Cloeon dipterum to different temperature conditions exposed to predation risk cues by dragonfly larvae. We ran a full-factorial laboratory experiment with a gradient of four temperatures covering current and future expected environmental conditions (18–27 °C) crossed with presence/absence of predation risk cues. We reared the mayfly larvae individually under unlimited food conditions and followed them until emergence. Overall, individual growth rates, development time and size at maturation were affected by temperature and initial body size but not by predation risk. Individuals of the same size grew faster and had shorter development at higher temperatures as expected. Surprisingly, the response of body size to temperature was unimodal with maximum size at intermediate temperature. Moreover, the effect of initial body size differed between sexes and temperatures. Our results show that aspects of individual ontogeny may overshadow biotic interactions in individual responses of ectotherms to climate change.

WARMING ADVANCES PHENOLOGY AND IMPACTS PRODUCER C:N:P STOICHIOMETRY IN ALGAE, SUBMERGED AND FLOATING MACROPHYTE DOMINATED SYSTEM

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Ever since the industrial revolution, global air temperatures have been rising at a rapid pace and are predicted to increase further over the coming century. Knowledge on how this warming will affect freshwater primary producers that form the base of the aquatic food web is essential to understand the functioning of these producers in the near future. Here, we performed a meta-analysis on data from three different indoor mesocosm experiments, namely an algae, submerged and floating macrophyte dominated system. These systems were exposed to a temperate seasonal temperature cycle and a warmed (+4°C) scenario. During these full-year experiments, we measured the growth and biomass of the primary producers and their C:N:P stoichiometry. Results showed that in the algae dominated system, warming led to lowered phytoplankton biomass and C:N and C:P ratios, which can be explained by an advanced zooplankton phenology and consumer-driven nutrient recycling. In contrast, periphyton biomass was initially higher in the warmed treatment, but a stronger grazer impact counterbalanced this effect. In the submerged macrophyte dominated system, warming led to an advanced growth of Myriophyllum spicatum, a prolongation of the growing season and higher macrophyte C:N ratios. In the floating macrophyte dominated system, producer growth accelerated with warming, and Spirodela polyrhiza became dominant at the expense of Lemna/Wolfia vegetation in the warm treatment. These results indicate a strong link between temperature and the phenology and C:N:P stoichiometry of producers and show how this can be mediated by herbivore grazing and nutrient recycling.

RESPONSES OF FRESHWATER INVERTEBRATE FAUNA TO THE ABRUPT 8.2 KA PALEOCLIMATIC EVENT: EVIDENCE FROM A SMALL MOUNTAIN LAKE IN THE CZECH REPUBLIC

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The 8.2 kiloyear cooling is one of the most abrupt climatic events to occur throughout the Holocene. Several studies from central Europe describe widespread ecological changes associated with the event, however, few studies document the response of freshwater invertebrate fauna. Here, we present a detailed paleoecological record from a sediment profile from Prášilské Lake, a small tarn in southern Czech Republic (1080 m asl, 3.7 ha, max. depth 15 m). Using XRF data and radiocarbon dating, we identified a disturbance sequence correlated with the 8.2 ka event (ca. 6300 years BC). A multi-proxy approach using lake fauna remains (chironomids, alderflies, bryozoans and in less detail caddisflies, mayflies, and cladocerans) supported by an analysis of aquatic and terrestrial plant macrofossils, pollen, charcoal and terrestrial insects was used to evaluate the ecosystem response on the event. Our results document an increase in both abundance and the number of species of macrozoobenthos (namely profundal chironomids), and changes in catchment vegetation cover during the event. A synchronous increase in Rubidium suggest increased erosion and more pronounced influence of tributaries which could have supported water column mixing in the humic brown-water lake generally affected by bottom anoxia. Plant macrofossils, pollen, charcoal and terrestrial insect communities also document an increase in humidity. This change in the hydrology, leading to higher oxygen concentrations near the bottom because of the mixing of the lake, would explain the observed expansion of macrozoobenthos. Our results thus indicate a strong indirect effect of the 8.2 ka event on the lake fauna.

IMPLICATIONS OF WITHIN-LAKE VARIABILITY FOR GLOBAL TRENDS IN LAKE SURFACE WATER TEMPERATURE

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Lake surface water temperatures (LSWTs) have previously been shown to be warming rapidly, and in some lakes to increase at a faster rate than local summer surface air temperature increases in response to climatic trends. Traditionally, however, LSWTs have been compared from a single location from different lakes, mostly from in situ monitoring data. In a global-scale analysis, we demonstrate the bias introduced by using single point measurements, as opposed spatially resolved satellite data, to understand LSWT warming. Using satellite-derived LSWT observations, we demonstrate considerable fine-scale warming differences within lakes and spatial variations in the amplification of LSWT response to atmospheric warming. Our results illustrate that comparisons of LSWT trends among lakes where sampling locations vary, can lead to biased interpretations of LSWT warming at a global scale. Using lake mean temperature trends from 144 lakes globally, we demonstrate that the degree of amplification in summer LSWT is variable, and is greater for high-latitude and deep lakes. Climatic modification of LSWT has numerous consequences for water quality and lake ecosystems, so quantifying this amplified response at a global scale is important.

EVALUATING THE INVASION OF CRASSULA HELMSII ON BIODIVERSITY AT A SITE OF NATIONAL CONSERVATION IMPORTANCE

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Non-native invasives (NNI) are a serious threat to aquatic ecosystems worldwide, with potential impacts for both biodiversity and economics. Crassula helmsii, an aquatic perennial plant originally from Australia is listed as one of the worst hundred European NNIs. It has steadily colonised different freshwater habitats across Europe since the 1950s when it was first recorded in the wild in England.

Evaluation of Crassula extent and specific impacts is critical to the assessment and potential mitigation of invasion. This includes: standardisation of methods for assessment of coverage; understanding the specific impacts at different spatial and temporal scales; and the availability of pre-invasion data to use as a baseline to aid interpretation of results. The Freshwater Biological Association, has collected worldwide freshwater data holdings over the last 80 years, an extremely valuable resource for baseline assessments. Use was made of this data during a survey of a tarn in the NW of England. This work was undertaken in the summer of 2016, to assess the coverage and potential impacts of Crassula (first recorded in 2010) on macrophyte biodiversity and other fauna of interest, at a site of conservation importance.

Despite its longstanding presence in Europe, there are still many unknown aspects to the ecology of this species. It is vital to understand them for the management, mitigation, control and eradication of Crassula. The aim of this paper is to open a discussion on utilising results from different studies to get a better understanding of the problem and ways forward to common solutions.

ARE FISH INVASIONS THREATENING ISOETIDS IN SHALLOW ALPINE PYRENEAN LAKES?

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Invasive fishes have been introduced for centuries in alpine Pyrenean lakes. By the year 2000, more than half of the 500 lakes from the Catalan Pyrenees were found to be invaded with major consequences for their biodiversity and functioning. Fish predation reduces amphibian juvenile abundance and may control the densities and sizes of macroinvertebrates and zooplankton. Such changes may also cascade down and threaten macrophyte populations but their potential impacts have not yet been reported. In this work we compare the benthic environment (i.e. sediment deposition, sediment respiration and organic content) and meadow structure (epiphyte load and macrophyte biomass allocation) in five shallow Pyrenean lakes vegetated with Isoetes lacustris. Two lakes were used as a reference without fishes, one with trout, and two with dense populations of Phoxinus sp. We encountered much larger (ANOVA $p < 0.001$) sediment deposition, sediment respiration and epiphyte load in lakes with Phoxinus sp. as expected from a eutrophication effect. Epiphyte composition from these lakes differed by the presence of low light tolerant cyanobacteria. In these systems I. lacustris showed significant changes in biomass allocation compared to control and trout lakes. These results show that the presence of dense Phoxinus sp. populations leads to a phase change from clear oligotrophic waters towards turbid conditions affecting the quality of water and sediment and threatening I. lacustris populations. Our results indicate that the impact is substantial and might result in a regression of the I. lacustris in these lakes.

HIGH TRAIT VARIABILITY IN A GLOBALLY INVASIVE CYANOBACTERIUM

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Biological invasions are severe threats to freshwater biodiversity. One globally important species is the tropic diazotrophic cyanobacterium Cylindrospermopsis raciborskii, which expanded its distribution worldwide in the last decades. The reasons of its invasion success are still not fully understood. In two experiments, under nutrient replete (eutrophic lake) and P-limited conditions (bloom) we investigated relevant ecophysiological traits in 12 genetically different isolates of C. raciborskii, from Northeast German lakes and determined how variable they are. C. raciborskii was highly variable and exhibited a wide range of nutrient ratios (C:N:P), growth rates, nitrogen fixation and grazing losses. However, we found no trade-offs between the two experimental conditions. The grazing loss of C. raciborskii depended on its filament length.

Our results imply that Cylindrospermopsis is adapted to both, P-replete and bloom conditions, reflecting a generalists behaviour. The invasiveness may be mostly related to the C to nutrient ratio under P-limitation and the subsequent P-uptake after P-pulses. This high flexibility appears to be more important than the ability to fix nitrogen or low grazing losses. Nevertheless, in a community context, a combination of various traits in relation to the ambient community will finally determine the invasion success.

EUTROPHICATION INCREASES THE INVASION SUCCESS OF A WIDESPREAD ALIEN FISH SPECIES

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Mediterranean river basins do suffer from severe human pressures and ecological menaces, being eutrophication one of them. This phenomenon has its origins on industrial and urban sewage, as well as an excess of fertilization with inorganic nitrogen on agricultural lands, which end on rivers and aquifers by means of water runoff. The Community legislation has addressed this problem through the establishment of Nitrate Vulnerable Zones in the Nitrates Directive. It is also concerning the effects of invasive species on our aquatic systems ecology, in particular the case of Eastern mosquitofish (Gambusia holbrooki) because of its character of global plague. In this study, we sampled mosquitofish in 18 littoral ponds in NE Iberian Peninsula along an eutrophication gradient at the beginning of the reproductive season. Reproductive parameters such as gonadosomatic index, brood size, embryo development stages and mean oocyte weight were related with water quality parameters at each location. Significant correlations have been found between the nutrient concentration and biometric variables, being nitrate an important factor affecting mosquitofish reproduction. In eutrophic ponds, a bigger brood size but smaller embryo weight was found compared to oligotrophic ponds. We suggest a trade-off between brood and oocyte sizes modulated by the environment available resources. This study demonstrates the adaptability of this invasive species to varying environment conditions and how this plasticity on its reproduction parameters has a big deal on its population success worldwide.

THE WELS CATFISH SILURUS GLANIS LINNAEUS, 1758 IN THE TIBER RIVER (UMBRIA REGION, ITALY): SPATIAL DISTRIBUTION AND ECOLOGICAL PR

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The aims of the research were: i) to analyze the Wels catfish Silurus glanis distribution in the Tiber River (Italy) 15 years after its introduction, and ii) to assess the environmental variables driving the presence of the species. The study area comprised the Umbrian portion of the Tiber River; fish and environmental data collected during the years 2002-2016 in 11 sampling sites were used. After the first record in 2002 in the Corbara Reservoir, the Wels catfish rapidly expanded its distribution range in the Tiber River. Currently the species is present with established populations both in the lake and in five sampling sites located on the Tiber River. The total length range of the specimens was 9.20-170.00 cm. The equation of the total length-weight relationship was W = 0.006 TL 3.014. As demonstrated by previous researches, the results of the CCA analysis have confirmed that the fish community composition changes gradually along the upstream-downstream gradient of the Tiber River in conjuction with the environmental changes; in this sequence the Wels catfish is positioned in the lower stream reaches, where the presence of the species is linked to poor environmental quality and it is associated with other non-native species, as Pseudorasbora parva, Barbus barbus, Carassius auratus and Rutilus rutilus. The rapid spread of Silurus glanis in the study area and the large sizes that characterize the specimens of the species suggested that its presence can lead to serious adverse ecological impacts on the native fish fauna, mainly due to predation activities.

INVASION EFFECTS ON NATIVE SPECIES: POSITIVE OR NEGATIVE?

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Ecologists neglect about parasite spillback or resource competition as a potential threat to native species in relation with energy flow during invasion. Invasions could have effect on ecological tolerance and geographic distribution of native species, predators and their parasites. But on the other hand, economists discuss about positive effects like Biological control or increasing catch per unit area during some invasions.
Taxonomical relation between native species and invaders are very important in invasive host –parasite coevolution. For example, population of native amphipods in central European rivers are progressively displaced by highly adaptive invasive species of amphipods with different salinity, temperature or drought tolerance. We hypothesized that deviations from normal behavior due to infection are more distinct in native species compared to the invasive one. According to our results invader amphipods (Echinogammarus berilloni) are less active and save energy to be used for survival in areas with high pollution and salinity. They also avoid predator odor more than native species. We discuss to what extent these results may explain the distribution patterns and invasion processes in relation to parasitism found in nature.

INVASION OF HEMIMYSIS ANOMALA IN THE LARGEST NATURAL FRENCH LAKE (LAKE BOURGET): TROPHIC ECOLOGY AND SPATIAL DISTRIBUTION

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Ecological invasions are a major threat for aquatic ecosystems. Since the last decades, Hemimysis anomala (Mysidae) colonized a large number of inland waters in Europe and North America. Yet, few studies addressed its trophic behavior. In this study, we documented the extent of the invasion of H. anomala in Lake Bourget, the largest natural French lake. Carbon and nitrogen stable isotope measurements were conducted among subpopulations in different regions of the lake as well as among different developmental stages to assess the possible trophic impacts of this species on the lake foodweb. H. anomala occurs all along the lake shoreline down to -15m with swarms reaching sporadically several cubic meters (> 10,000 individuals). Stable isotopes revealed low overlapping of the trophic niche space among subpopulations suggesting an important plasticity in the trophic behavior of H. anomala. Specifically, subpopulations inhabiting gentle slopes were more related to benthic resources while those inhabiting steep slopes were more supported by pelagic resources. The different developmental stages also exhibited significant differences in their stable isotope signatures attesting of changes in trophic behavior with ontogeny. On the average, the trophic position of the species falls between those of zooplankton / benthic invertebrates and those of fishes. Our results indicate that H. anomala acts as an opportunistic intermediate predator that may possibly disrupt energy flow in the lake food-web.

INCONSPICUOUS THREAT: COMPARISON OF FORAGING PATTERN OF TWO NON-INDIGENOUS GOBIID FISHES IN A SIMPLE PREDATOR-PREY SYSTEM.

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Recently, non-indigenous round goby Neogobius melanostomus (Pallas, 1814) and tubenose goby Proterorhinus semilunaris (Heckel, 1837) expanded substantially, possessing threat to the freshwater and brackish ecosystems. These species has detrimental effect on fish community structures via direct preying on fish eggs and larvae. In this study we compare the foraging patterns of these predators preying on common carp larvae (Cyprinus carpio) using functional response (FR) approach at two temperature levels. Both FR parameters, search rate and handling time, showed no significant temperature dependency suggesting wide temperature optima in both species. In the interspecific comparison, the only significant difference showed the search rate at 20 °C to be higher in Proterorhinus semilunaris, indicating more effective resource acquisition at low prey densities. Insignificantly lower handling times of Neogobius melanostomus at 25 °C reflected slightly higher maximum consumption rates of this species at higher temperatures. Besides these differences, both studied predators exhibited substantial consumption rates, indicating ability to negatively impair invaded ecosystems.

FISH BIODIVERSITY OF AEGEAN REGION (TURKEY): CURRENT STATE OF KNOWLEDGE AND CONSERVATION IMPLICATIONS

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Freshwater fish fauna of Turkey is rich in term of biodiversity and endemism counting species of both European and Asian origin. Turkish Aegean Region hosts a high number of endemic species and falls within Mediterranean biodiversity hotspot. Nevertheless, current knowledge on endemic fauna is limited and for some species the taxonomic status is still unsolved.

This study aims to update information on freshwater fish biodiversity of Aegean Region of Turkey with main attention on endemic species and their conservation status.

A complete literature survey of all available data and information on distribution, ecology and biology of these species was carried on. The data were cross-checked and supplemented by information on their conservation status and recently taxonomy and then integrated with new data collected directly on the field.

The results underlined that some endemic species are currently listed as Data Deficient in the Red list of IUCN and often their exact geographic distribution is still unknown. Several species are restricted to very small areas and this makes them more sensitive and exposed to human impacts. Habitat loss and degradation, drought and excessive water abstraction are the main threats affecting the fauna but a further pressure is represented by the massive presence of alien species mainly introduced for restocking purpose.

Further researches focusing on these species are strongly encouraged together with proposal management actions for conservation purpose.

DIFFERENTIATIONS IN GILL HISTOLOGY OF MARINE FISH ATHERINA BOYERI RISSO, 1810 (ATHERINIDAE) INTRODUCED INTO FRESHWATER ENVIRONMENTS

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Gills in teleost fish are multifunctional organs responsible for respiration, osmoregulation, ionic regulation, acid-base balance and excretion. Especially in euryhaline fish, gills have an important function in osmoregulation. The marine fish sand smelt (Atherina boyeri) naturally inhabits coastal and estuarine waters in Mediterranean, Black, Azov and Caspian Sea basins. But, this euryhaline species has been unintentionally introduced into freshwater environments and became an successful invasive in Turkey. Today, it has permanent freshwater resident populations in Turkey and it is considred as invasive in inland waters. The aim of the present study was to assess the histological differentiations in the abundance of chloride cells in gills between natural (marine, brackishwater) and translocated (freshwater) populations of A. boyeri. Fish samples were obtained from 11 different locations; 6 marine, 1 lagoon and 4 freshwater populations were sampled. Gills of the fish samples were removed, histological slides of the gill arches were prepared and dyed with Hematoxylin & Eosin. A section (50x120 µm) of the gill flament were observed for each individual fish and the number of chloride cells were counted. Number of chloride cells ranged between 18-50 in sea, 30-48 in lagoon, 30-57 in freshwater samples. The results have suggested that the low salinity has caused an increase in number of chloride cells. This difference in abundance of chloride cells between freshwater and sea populations of sand smelt can facilitate its invasion in different environments with various salinity. Osmoregulation performance seems to have important role for establishment success of this invasive species.

A REWIEV ON DISPERSION OF MARINE FISH ATHERINA BOYERI RISSO, 1810 (ATHERINIDAE) IN INLAND WATERS OF TURKEY

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Sand smelt (Atherina boyeri) is a marine fish naturally distributed costs of Mediterranean, Black, Azov and Caspian Sea basins and east of Atlantic Ocean. This species can enter estuaries and lagoons connected with sea due to its euryhalin character. Peculiarly, it has been introduced into freshwater environments for vorius purposes and established permanent freshwater populations. The species inhabits all sea coasts of Turkey and it has also been translocated into freshwater lakes and reservoirs isolated from sea. A. boyeri was firstly recorded from Lake Sapanca. Thereafter, many new records about this species were obtained from various lakes, ponds and reservoirs located on Sakarya, Aksu, Kızılırmak, Ceyhan and Orontes River basins during last three decades. Recently, it was found in Aslantaş, Obruk, Kılıçkaya, Süreyyabey and
Babaoğlu reservoirs and Hoyrat Lake. Today, it is present in 23 natural and 17 artificial freshwater habitats in Turkey. Based on official informations, freshwater populations of sand smelt is an important component of inland fisheries in Turkey. A. boyeri has many traits that contribute to its success in freshwater habitats a invasive species such as broad salinity tolerance, early sexual maturity, high reproductive capacity, short life-span, fast growth and opportunistic diet. Indeed, we found similar growth performance in native marine and translocated freshwater populations of A. boyeri. High fecundity, prolonged reproductive season and broad food preference were also evident characteristics in freshwater populations. Our studies on A. boyeri indicated that this species is a potential risk for freshwater biodiversity in Turkey.

THE FRESHWATER SNAILS OF CRETE: AN UPDATED LIST OF NATIVE AND INVASIVE SPECIES

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New data on the freshwater gastropods of the island of Crete (South Aegean Sea, Greece) are presented. We surveyed the gastropod fauna of 18 freshwater systems including springs, brooks, streams, lakes and estuaries located mainly in the west part of the island. In total, eleven species belonging to ten families were recognized morphologically and anatomically. Knowing the existing problems in the taxonomy and classification of freshwater snails, molecular data were also used to clarify the taxonomic status and assess the phylogenetic relationships of the species found. Based on mtDNA sequence data and morphological diversification new and undescribed freshwater lineages are likely to be present in the island. The mainland species Radix auricularia (Lymnaeidae) is reported for the first time from Crete. Potamopyrgus antipodarum (Tateidae), a prosobranch snail native to the fauna of New Zealand that has invaded many European countries so far, is recorded from a single location. This is the second time that the species has been reported from Greece and the first report from an insular system.

LONG-TERM ZOOPLANKTON COMMUNITY PATTERNS IN LAKE CHAMPLAIN, USA: THE ROLE OF INVASIVE SPECIES IN RE-STRUCTURING LAKE FOOD WEBS

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Freshwater lakes provide ideal habitat for invasive species that may deteriorate ecological integrity by altering food web dynamics. Long-term records (1992-present) for native Mysids as well as native zooplankton (Rotifers, Cladocera, and Copepods) in Lake Champlain illustrate the impact of invasive species on the pelagic food web. Zooplankton exhibited major shifts from 1992-present, including a decline in rotifer abundance in the mid-1990s, a pattern that is linked with the invasion of zebra mussels (Dreissena polymorpha) into Lake Champlain. More recent community shifts can be attributed to invasion of the Alewife (Alosa pseudoharengus) and Spiny Waterflea (Bythotrephes longimanus). These shifts represent a major change in community structure with implications for the Lake's food web dynamics. The primary driver of change in Lake Champlain's plankton over the past two decades appears to be species invasions. Long-term patterns in community composition were not correlated with changes in the Lake's water quality or trophic status. Zebra mussel invasion in Lake Champlain impacted Rotifers via direct predation with potential indirect effects on Cladocera, Copepods, and Mysids. Impacts of Alewife and Spiny waterflea invasion in the mid-2000s and 2014, respectively, occurred on selected larger bodied Cladocera and Copepod taxa. Post- invasion patterns in Lake Champlain's pelagic plankton communities illustrate the threat that invasive species pose to the integrity of freshwater ecosystems.

THE CRAYFISH PLAGUE PATHOGEN APHANOMYCES ASTACI AND ITS POTENTIAL DISPERSAL PATHWAYS IN EUROPE LINKED TO ORNAMENTAL TRADE

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Native European crayfish species are threatened by habitat loss, deteriorating water quality, and most importantly by non-native crayfish species and crayfish plague (disease caused by an oomycete Aphanomyces astaci). This pathogen, listed among 100 of the world's worst invasive alien species, has caused substantial and so far irreversible declines in native crayfish populations. Although A. astaci natural hosts and main vectors, the North American crayfish, have been introduced to Europe mainly through aquaculture and stocking to open waters, the trade in ornamental crayfish has recently gained in importance as a prominent introduction pathway of these freshwater crustaceans. Therefore, it may represent a source of exotic pathogens, including A. astaci, and pose a risk of crayfish plague transmission to European crayfish. Moreover, although susceptible to A. astaci infection, even ornamental crayfish of non-American origin may contribute to crayfish plague spread, if widely traded species exhibit elevated resistance. Similarly, other freshwater decapod species may facilitate A. astaci transmission if growth of this crayfish-specific pathogen is possible in their tissues. The presentation will summarize outcomes of three projects that focused on 1) presence of A. astaci infection in crayfish from ornamental trade, 2) resistance of Australian crayfish, Cherax destructor, to crayfish plague pathogen, and 3) potential of ornamental shrimp species to acquire and transmit A. astaci infection. These outcomes will be discussed in relation to existing regulations and potential preventive measures aiming to reduce the risk of A. astaci spread.

ANALYZING FUTURE COMPETITION BETWEEN NATIVE AND NON-NATIVE SNAIL SPECIES IN THE LOWER EBRO RIVER (NE SPAIN)

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Rivers are ecosystems especially vulnerable to biological invasions. Modifications of aquatic habitats, flow regulation and water abstraction affect native species and create the conditions suitable for tolerant non-native species.
In 2010, the apple snail (Pomacea maculata) invaded rice fields in the Ebro River Delta causing devastating effects due to its diet flexibility and high reproductive rate. Currently, the snail is also present in some wetlands, and it has been found moving upwards along the Ebro riverbed. The native endemic species Melanopsis tricarinata lives in the same area, and will have to compete with the apple snail in the next future.
The present study aims to experimentally analyse, the response of both species to changes in temperature and dryness, factors that will increase in future scenarios of climate change. In addition, we study their diet in natural conditions to determine potential food competition.
The lower part of the Ebro is highly regulated. Flow changes determine differences in water level, periodic dry/wet conditions where the non-native species could have advantages. In this sense, we have also modelled the surface of riverbed emerged according to different flow management conditions.
Results show that P. maculata supports better dry conditions and higher temperatures regarding to M. tricarinata. Stable isotopic analyses determine that diet of both species is similar with high niche trophic overlapping. Flow reduction increases the habitat that favours non-native species. We found high risk of competition and greater survival for the non-native species that would favour its spread.

IS THE AMMONIA CONCENTRATION A POSSIBLE INVASION BARRIER FOR THE INVASIVE AMPHIPOD DIKEROGAMMARUS VILLOSUS?

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The invasive amphipod Dikerogammarus villosus has successfully colonized many different freshwater habitats in large parts of Europe. Because this species is regarded as a potential threat for native biodiversity as well as an important species controlling ecosystem functions, its distribution pattern is of special interest. The colonization by this tolerant species is usually restricted to larger rivers, while smaller tributaries are rarely inhabited. However, the particular drivers for this distribution pattern are yet unknown. Several biotic and abiotic factors could explain the formation of a natural “invasion barrier” preventing further dispersal upstream. We found evidence that concentration of ammonia might be one factor limiting penetration of D. villosus to smaller streams. We measured longitudinal gradients of ammonia concentration in three German streams and found that in the two smaller water courses high maximum values coincide with the limited distribution of D. villosus. Other authors have already determined the relatively low tolerance of D. villosus to ammonia compared to other amphipods, indicating the potential of this environmental factor to control D. villosus distribution. Our findings therefore highlight the importance of an environmental factor that has been largely overlooked as a potential key for shaping stream communities and mediating competitive interactions between amphipod species.

EVOLUTIONARY HISTORY OF AN ANCIENT CYPRINID GENUS FROM SOUTHERN EUROPE

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Pelasgus (Cyprinidae) is an ancient fish genus endemic to the southern part of the Balkan Peninsula. It comprises seven species. Using a multilocus approach we studied phylogenetic relationships within the genus and revised distribution areas of its species. We covered the known distribution range of the genus by analyzing 183 specimens from 47 localities, including the type localities of all species. One mitochondrial (cytochrome b) and three nuclear markers (the first intron of ribosomal protein S7, recombination activating gene RAG1 and rhodopsin) were used. Cytochrome b confirmed the existence of seven well supported lineages. Of three nuclear markers, S7 revealed six well supported clades, while RAG1 and rhodopsin appeared to be less informative, revealing only four well supported clades due to low variability and haplotype sharing between some of the species. Molecular identification has allowed reshaping the knowledge of the distribution areas for the species of the genus. The introduction of one Pelasgus species is suggested in three localities. As a consequence, sympatric occurrence and hybridization of two species has been revealed.

INTER- AND INTRASPECIFIC CHEMICAL COMMUNICATION BETWEEN NATIVE AND ALIEN GAMMARIDEAN SPECIES (AMPHIPODA: CRUSTACEA)

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The invasion of amphipods and the consequences to the native ecosystems is a recent discussed topic in limnology. A so far not observed aspect are potential displacement mechanisms by invasive species through interspecific chemical communication with native species. Using Echinogammarus berilloni as example, a species that originates from the Basque country and dispersed over France to the Benelux countries and Germany, it was tested in how far there might be waterborne chemical communication between the invader and the native amphipods Gammarus pulex and Gammarus fossarum.
To date, two activity tracking experiments were conducted, one with each single specimen and one with groups of native vs. invasive amphipods. In both setups aquaria were divided by a double mesh to two compartments, where different combinations of sex and species could be tested and compared to the respective controls. The experiments revealed different activity patterns of the species over time, and as well differences in activity between intraspecies and interspecies setups with a strong gender specific influence on activity. In general, it was shown, that the presence of E. berilloni leads to a decrease in activity of the native species, whilst the activity of E. berilloni is hardly influenced by their chemical cues, which indicates that E. berilloni uses chemical cues as allomones in order to displace G. pulex and G. fossarum.

INTRASPECIFIC COMPETITION – A RELEVANT PHENOMENON IN THE INVASIVE AMPHIPOD DIKEROGAMMARUS VILLOSUS?

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The invasive Ponto-Caspian amphipod Dikerogammarus villosus is widely considered as a main cause for the decline of native benthic biodiversity in large European rivers. Recent observational field studies indicated that D. villosus can be not only a predator but also a superior competitor for other benthic invertebrates. In the invaded ecosystems, it quickly builds up very high densities, which might be expected to result in a strong intraspecific competition. We evaluated whether this is a relevant regulating mechanism in this species, affecting its fitness and invasion success.

We performed four field mesocosm experiments manipulating the density of D. villosus, and analysed its effects on the benthic community of the Rivers Elbe and Rhine including intraspecific competition at different densities. To study intraspecific competition, we quantified the invader's food consumption and physiological fitness indicators (energy storage components, RNA:DNA ratio). In addition, the consumer-density dependent functional responses of D. villosus and Gammarus roeseli were determined in a laboratory experiment.

D. villosus showed constantly high food consumption rates in the mesocosms and no negative effects of high densities on food consumption or physiological fitness. The laboratory-measured leaf consumption rate increased with consumer density up to beginning saturation at very high densities for both amphipod species. All results indicate that intraspecific competition in D. villosus is either very weak or can be easily compensated, and therefore is probably not a regulative mechanism. The invader rather seems to benefit from high densities, but it might share this trait with other amphipods.

DO POOLS IMPEDE DRIFT DISPERSAL BY STREAM INSECTS?

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Drift of stream insects is one of the most ubiquitous forms of downstream dispersal and thought to be a key factor influencing the persistence of local populations. Identifying the factors that limit drift dispersal between habitat patches is needed to understand of the connectivity of insect populations along river channels. We determined whether insects drifting between riffle habitats (i.e. patches of suitable habitat) were impeded by natural, slow-moving pools (i.e. unsuitable habitat), limiting dispersal to the next downstream riffle, by estimating drift rates entering and exiting pools. We found that for 8 of 9 study taxa, drift dispersal between riffles was significantly hindered by the intervening pool habitat. There were three taxa whose drift rates were significantly reduced by at least one increasing measure of pool morphology – Offadens hickmani, Austrophlebioides spp. and Austrosimulium spp. Additionally, pool morphological measures were associated with Coloburiscoides munionga and Asmicridea sp. AV1, but more weakly at $P<0.10$. These relationships were consistent with the prediction that dispersal was increasingly impeded with greater areas of low or zero flow velocity within pools. Overall, our results suggest drift dispersal seems unlikely to be a major mechanism of long distance dispersal, with a significant proportion of drifters dispersing less than a few kilometres from a source riffle habitat. These findings indicate that drift may play a more limited role in stream insect dispersal than is commonly considered and that flying adults may therefore have much greater influence on connectivity amongst populations.

FINE SCALE DRIVERS OF MACROINVERTEBRATE COMMUNITY ORGANIZATION IN RHITHRAL SECTIONS OF PERENNIAL STREAMS

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Macroinvertebrate community organization at small scale is generally studied within the environmental filtering framework, disregarding processes other than those based on abiotic factors. Space is currently used as an explicit predictor to distinguish between environmental filtering and biotic processes at large and medium sized scales, but is often neglected at smaller scales. The aim of this work was to investigate how environmental and spatial variables affect macroinvertebrate community organization. To this purpose, we carried out a work in three rhithral sections of perennial streams located in the Po Basin (Northern Italy) by means of specific in situ 50-points random sampling grids. Benthic Organic Matter (BOM), velocity, depth and substrate were collected, as environmental factors, together with spatial coordinates for each sample. Coordinates were used to produce Principal Coordinates of Neighbour Matrices (PCNM) in order to detect additional spatial structures. Data were analysed by means of variance partitioning methods, considering spatial coordinates, PCNM and environmental factors as groups of explanatory variables. Environmental factors (primarily BOM), both with and without spatial structure resulted the main drivers affecting taxa richness, abundance and community composition. On the other hand, coordinates and PCNM accounted for a minor fraction of explained variance. Our results suggest that trophic factors are useful predictors of macroinvertebrate community organisation in rhithral sections of perennial streams. Restoration ecology, habitat suitability modeling and biomonitoring sampling methods could benefit from our approach.

FUNCTIONING OF POPULATION OF RACER GOBY AT THE EDGE OF THEIR RANGE

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Spatial and temporal variation in the abundance of species can often be ascribed to variation in the surrounding environment. Distribution, abundance and structure of populations are determined by interacting abiotic and biotic factors. Ichthyobiologists know the functioning of many fish species in ecosystems, but the knowledge of how marginal populations, living at the edge of their range function, is still incomplete and therefore extremely interesting. Our study was conducted for 15 years for from 2001 to 2016. The research focuses on the factors affecting distribution, and dynamics of marginal population of racer goby Babka (Neogobius) gymnotrachelus living in mountain stream, close to their tolerance limits with regard to water current. The specific objectives of the study were factors affecting local patterns of the species, long-term dynamics of the species, and the role of small-scale habitat heterogeneity. The study was conducted in the Polish part of the Strwiąż River (a tributary of the Dniester River; Black Sea basin). The studied sections of river and streams were a pebble-cobble bottom mountain watercourses, with an width ranging from 2.0 to 10.0 meters. Fish assemblages of eighteen sampling sites in the upper Strwiąż River catchment were analyzed. Suitable habitats for goby were, among others, boulders, that provide great hiding places for adult fish, and shallows with sediments - the appropriate places for fry growth. Our study shows that population of racer goby in Strwiąż River, at the edge of their range, is largely determined by small-scale habitat heterogeneity.

RELATIVE ROLE OF DRIVERS ON MACROINVERTEBRATE METACOMMUNITY STRUCTURE IN SMALL STREAMS AND HIGHER ORDER RIVERS

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Environmental control and spatial structuring are the most common processes which regulate local community structure within a metacommunity. The effect of these factors is highly dependent on species traits and characteristics of the studied area. We investigated the impact of drivers on temporal structuring of aquatic macroinvertebrate dispersal mode groups (aquatic passive dispersers; terrestrial active and terrestrial passive dispersers) within a metacommunity in small streams and higher order rivers using overland and watercourse distances. We hypothesized that the relative role of environmental control and spatial structuring on metacommunity dynamics should have a temporal variability in streams and rivers. We predicted that active dispersers might be influenced mostly by environmental control and both environmental and spatial factors have an effect on passively dispersing species. We also expected that watercourse distance is a better spatial predictor in the case of the aquatic passive group, while terrestrial dispersal groups are predicted by both distances. We applied partial redundancy analysis based on quantitative abundance data from two seasons and Moran's eigenvector maps based on overland and watercourse distances. Results showed seasonal differences in the impact of environmental control and spatial structuring. The effects of these drivers were detectable more clearly in summer than in spring. We found strong environmental control without spatial structuring on active dispersers in both seasons and passive dispersers were influenced by environmental factors with low impact of the spatial component. We detected only minor differences in all dispersal groups using overland and watercourse distances.

LINKING MULTIPLE SCALES OF HYDROMOPHOLOGICAL DETERIORATION TO BENTHIC MACROINVERTEBRATE HETEROGENEITY

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The structure and functions of stream systems reflect the deterioration caused by different types of human induced pressures, particularly hydromorphological adjustments. While the importance of this complex relationship is widely accepted, empirical evidence does not necessarily support it. This study addresses the complex linkages between hydromorphological changes at different spatial scales and benthic macroinvertebrate communities, aiming to reveal the patterns and gain some perspective into the processes that underpin them, emphasizing the importance of microhabitat level approaches. Eleven study sites were preselected in Prahova River Basin, Romania based on catchment and streams physico-chemical characteristics. Subsequently, they were classified along a gradient of hydromorphological deterioration based on the type and extent of hydromorphological impairments assessed at a variety of scales ranging from microhabitat to mesohabitat, reach and catchment. Using descriptive and multivariate statistical analysis, we identified the main variables that explain the deterioration and the spatial scales associated with them. We also revealed the most vulnerable species and a decrease of the overall macroinvertebrate heterogeneity (explained by taxonomic richness, abundance and diversity) along the hydromorphological gradient. Foremost, in order to determine the causal links between selected hydromorphological variables and benthic macroinvertebrates regression analyses were used. Outcomes concerning the linkages between both the biota and hydromorphology and the patterns and processes revealed the need to consider trait based approaches when dealing with biological communities responses.

PHYTOPLANKTON DIVERSITY IN THE CONGO RIVER

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Phytoplankton samples were collected in the Congo River along a 1700 km stretch between Kisangani and Kinshasa during high water (HW, December 2013) and falling water (FW, June 2014). Phytoplankton was sampled in the main river, in tributaries and nearby lakes, and measurements of various relevant environmental variables were carried out. Biomass and composition were determined by HPLC analysis of chlorophyll a and marker pigments and by microscopy. Chlorophyll a concentrations differed between the two periods studied: in the mainstem they varied between 0.07 and 1.77 µg L-1 in HW conditions and between 1.13 and 7.68 µg L-1 in FW conditions. Green algae dominated in the mainstem in HW, whereas diatoms dominated in FW; cryptophytes and cyanoprokaryotes were more abundant in the FW period, both in the tributaries and in the main channel. In a first study devoted to phytoplankton production and growth, we showed that phytoplankton growth in the Congo River mainly took place in the main channel, with hydrological processes allowing maintenance of phytoplankton biomass even in HW. Here we explore how phytoplankton diversity changed along the river course in FW, depending on inputs from tributaries and on development in the main channel. Taxonomic richness was high, with a major contribution of diatoms, green algae and cyanoprokaryotes, and was well correlated to chlorophyll a, suggesting that similar processes determined both phytoplankton abundance and diversity in this very large river.

COMBINED EFFECTS OF MULTIPLE STRESSORS ON STREAMS BIODIVERSITY AND ECOSYSTEM FUNCTIONS

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Multiple stressors of anthropogenic origin have impacted ecosystems worldwide. A particular concern for streams is represented by multiple stressors introduced simultaneously by hydromorphological changes and riparian invasive plants. The combined effects of these multiple stressors on streams biodiversity and ecosystem functions are poorly understood. This represents a critical limit for an effective management of stream and for identification of appropriate remediation measures. We assess the response of four invertebrate communities consisting of three benthic macroinvertebrates species (two Plecoptera and one Trichoptera) to changes in food quality (from 100% Alnus up to 100% Fallopia) and accumulation of fine sediment which are widespread stressors affecting streams. We also varied the community composition in order to observe the effects of the biological diversity on litter decomposition under different level of stress. 300 microcosms, and 60 treatments were used in a lab experiment that lasted for 14 days. Several response variables were affected by one or more stressors. We discuss the effects on stream community observed to each sediment addition and increased proportion of organic matter provided by the invasive Fallopia species. Combined stressors effects and the possibility to predict them from knowledge of single-stressor effects in such stream community are also discussed.

IS COMPETITION GOOD FOR GROWING? HOW INTERSPECIFIC COMPETITION AND RESOURCE AVAILABILITY EFFECT NEMATODE GROWTH RATES

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Processes that shape community patterns act on all ecological levels: from individuals over populations to ecosystems. On local scales, biotic interactions are often cited as even more important drivers for community assembly than abiotic factors. In this study we investigated the effects of interspecific competition in a laboratory environment on the population growth (r) of two co-occuring nematode species (Panagrolaimus sp, Poikilolaimus sp.) under different bacterial densities. We started each treatment with 48 nematodes but with different ratios of species (0:48; 32:16; 14:14; 16:32; 0:48); hypothesizing that: 1) Species ratios influence r, so that the species which is outnumbered show higher values. 2) This effect is stronger under a low resource availability. To test these hypothesis, we applied a Generalized linear mixed model. The model selection process revealed that inclusion of the factors: species, bacterial density, species ratio and the interactions of bacterial density and species and species ratios, significantly improved the model. Our results confirm hypothesis 1) indicating an increase of r with decreasing number of individuals. Although we found a significant interaction of species ratio and food availability we could not find evidence for hypothesis 2) because the increase of r was strongest at middle food density and lowest regarding the lowest. Nevertheless our experiments clearly demonstrate that those two nematode species are able to adapt their growth rate when the other species is present. A mechanism that might play an important role in colonization of habitats and in maintaining coexistence of species within the same ecological niche.

CATCHMENT LAND COVER ALTERATION OF FOOD RESOURCES AFFECTS STREAM COMMUNITY SIZE SPECTRUM

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River food webs are predominantly powered by two food resources: in-stream produced organic matter in the form of biofilm or macroalgae and terrestrially derived organic matter as leaf litter. These food resources are highly dependent on the catchment vegetation land cover, especially in mountain streams, as these ecosystems are strongly connected to their watersheds. Therefore, we can expect catchment land cover to determine stream food resource availability and highly influence stream ecosystem structure as they also differ in quality (chemical characteristics: i.e. carbon to nutrient ratios). Food resource quantity and quality might affect not only the community taxonomic composition but also the size and density of organisms because of changes in feeding rates, growth and/or maximum body size of principal consumers. In order to explore the effects of catchment land cover on stream community structure, we analyzed body mass -abundance relationships (size spectrum) in 10 mountain streams within a land cover gradient (from grasslands to densely forested catchments). Size spectrum slopes were constant with a mean slope of approximately -0.8 without differences among streams, what suggested a common scaling relationship at different trophic levels. However, both resource quantity and quality affected organism abundance as revealed by changes in the intercepts of the size spectrum and the proportion of big to small organisms. Thus, the body mass - abundance relationships revealed important changes in community structure with land cover as a consequence of differences on food resource availability.

DISENTANGLING THE EFFECTS OF HYDROLOGY AND PREDATION ON MACROINVERTEBRATE COMMUNITY ASSEMBLY: A FIELD EXPERIMENT

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Despite the recognition of floodplains as biodiversity hot-spots, their ecological state is in decline worldwide due to human activities including flow regulation or channelization. It is well established that lateral habitats such as ponds contribute disproportionally to biodiversity in alluvial floodplains, and management models should incorporate the dependencies between hydrology and the functioning of these habitats if they are to preserve biodiversity in the long term. But while biotic interactions and especially predation or competition are expected to exert a strong control on community structure in these habitats during phases of hydrological isolation, the relative effects of abiotic forcing and predation on macroinvertebrate community assembly remains largely unknown.

To examine the relative effects of hydrology and predation on the assembly of the invertebrate community, we excavated 24 ponds in a gravel bar of the Maggia River in Switzerland. The ponds were filled by exfiltration of hyporheic water and we distributed them in 8 blocks of 3. Each block was characterized by a different water residence time (our hydrological variable), and within each of theses blocks, 1 pond received 6 juvenile brown trout, the other received 2, while the third pond remained fishless.

Physico-chemical parameters as well as peryphyton growth and macroinvertebrate community structure were monitored for 8 weeks in Summer 2016. Preliminary result suggest that different hydrological regimes create different physicochemical environments and affect primary production, while macroinvertebrate community assembly appears to be mostly affected by fish density.

GOING DOWNSTREAM: BETA DIVERSITY PATTERNS OF DIATOMS COMMUNITIES IN FRESHWATER ECOSYSTEMS

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A central question in community ecology is how environmental and dispersal-related processes control the patterns of beta diversity, including species replacement (turnover) and species loss (nestedness). The relative contribution of these processes is still unclear, especially in freshwater ecosystems. To address this deficiency, we assessed the relative influence of environmental filtering, mass effects and dispersal limitations along the watercourse on diatom taxonomic and functional beta diversity. We used a random sample selection to examine the variation of nestedness and turnover components according to watercourse position across 2194 sites in France. We explored the variation of taxonomic and functional beta diversity explained by pure environmental and spatial factors and correlated beta diversity values to environmental variables indicative of anthropogenic effects. The turnover component of beta diversity was largely predominant. Together with total beta diversity, it showed a decrease downstream. Environmental conditions exerted a major influence on beta-diversity patterns, with anthropogenic factors homogenizing communities regardless of watercourse position. The influence of spatial factors increased along the longitudinal gradient. The functional beta diversity significantly changed along the watercourse and its relation with pure environment and spatial factors appeared to be guild dependent. We concluded that environmental filtering was influential along the watercourse, while spatial factors, most likely related to mass effects, were more pronounced at mid- and downstream locations.

FLOW REGULATION AS A DRIVER OF MACROINVERTEBRATE SEEDBANKS IN GRAVEL BARS

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Gravel bars along natural flowing rivers experience contraction-expansion phases that shape local faunal assemblages, including riparian (terrestrial) spiders and beetles. Less is known about the role of gravel bars as temporary habitats for aquatic macroinvertebrates during dry periods, surviving via interstitial moisture (active seedbank) or as resistant forms (dormant seedbank). Macroinvertebrate seedbanks are an important source of recolonists to surface waters following gravel-bar inundation as well as a significant subsidy for terrestrial organisms. In flow-managed rivers, natural wet-dry periods have been artificially modified, e.g., through an increase or decrease in the frequency and magnitude of wet-dry periods (residual flows, hydropeaking). We investigated the presence/absence, density, taxa richness and assembly of active and dormant aquatic macroinvertebrates of gravel bars in five floodplains in Switzerland with different flow regimes (natural, residual, and hydropeaking). We sampled the dry sediments to assess active seedbanks and then rewet them in the laboratory to evaluate dormant seedbanks. We found that several taxa inhabited gravel bars as both active and dormant seedbanks, mostly Oligochaeta and Chironomidae. The presence/absence of macroinvertebrates showed high variability among locations, suggesting site dependent conditions influence seedbank properties. The density of active seedbanks was greater at rivers affected by hydropeaking, and lower in residual-flow than natural-flow rivers. These results emphasize the importance of gravel bars as habitats for aquatic macroinvertebrates and thus their inclusion in flow management schemes as well as conservation/restoration programs.

FUNCTIONAL REDUNDANCY AMONG BENTHIC GRAZERS: A STUDY ALONG LARGE-SCALE LONGITUDINAL GRADIENTS IN RIVERS

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Functional redundancy (FR) describes the coexistence of different species performing equivalent functional roles in ecosystems. FR is assumed to increase resistance of ecosystem functioning against species loss but its existence and significance in ecosystems is controversially discussed. As an attempt to detect spatial patterns of FR, the community of macroinvertebrate grazers was studied along large-scale longitudinal gradients in German highland rivers. It was hypothesized that (i) functional similarity of coexisting macroinvertebrate grazer taxa changes along longitudinal gradients and (ii) anthropogenic disturbance results in a homogenization of functional traits in the community.
Sampling took place in spring 2015 along 3 highland rivers in Saxony and Bavaria. At each river, benthic macroinvertebrates were sampled in riffle habitats at 3 sites from epirhithral to hyporhithral. Data on abundance and biomass of the occurring macroinvertebrate grazers was combined with information on important functional traits from the literature to calculate indices of taxa diversity and functional diversity. As a measure of functional similarity (clustering of taxa in functional trait space) mean nearest-neighbor distance (MNND) was calculated. Using a randomization procedure, the observed MNND was examined for any tendency of grazer communities to differ from the degree of clustering in simulated communities.
Results show an increase in the degree of clustering of grazer taxa in functional space from upstream to downstream sites in the studied rivers. This higher degree of clustering might be the result of stronger anthropogenic degradation and subsequent trait homogenization.

SHIFTS IN BETA-DIVERSITY DETERMINANTS FROM LOCAL TO GLOBAL SCALES: THE CASE STUDY OF AQUATIC DIATOM COMMUNITIES.

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Mechanisms of microorganism spatial distribution have been discussed extensively by ecologists and the idea that microorganisms exhibit biogeographical patterns is accepted today. Anyway large scale studies remain scarce, in particular for diatoms that are yet key components of river ecosystem functioning.
In this context, we explored how diatom β-diversity evolves according to the spatial extent, in a large scale dataset gathering around 3000 samples from France and the US. As β-diversity represents a fundamental key to understand the influence of processes on assemblages, we also proposed to highlight the relative role of local and regional variables in generating community dissimilarity, at various spatial scales. We started from 3 hypotheses: (1) β-diversity in diatom communities increases from local to larger scales; (2) β-diversity in natural conditions should always be higher than β-diversity in impacted conditions whatever the scale; (3) β-diversity patterns should be controlled by both local and biogeographical conditions in non-impacted sites and only by biogeographical conditions in impacted sites.
To test these hypotheses, we classified our sites along an anthropogenic gradient of nutrient enrichment. To evaluate β-diversity shifts across different scales, a landscape windows approach was used. We measured β-diversity following Baselga approach.
Our results supported our hypothesis, in particular the idea that diatom communities in natural conditions are shaped by both biogeographical and local variables, promoting speciation and resulting in a wide pool of specialists. Conversely, anthropogenic stressors promoted generalist taxa, resulting in a β-diversity decrease in impacted diatom communities, where only biogeographical variables exert a significant influence.

UNDERSTANDING THE ROLE OF DISSOLVED ORGANIC NUTRIENTS IN THE COMPOSITION OF RIVERINE ALGAL COMMUNITIES ALONG A NUTRIENT GRADIENT

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Organic matter loading to freshwaters is increasing. As a result, increases in dissolved organic nutrients may be contributing to the enrichment of rivers and lakes leading to changes in algal productivity and community composition. While increases in inorganic nutrients are known to alter algal communities, the role of organic nutrients in promoting these changes has received little attention to date and few studies have considered how this may vary at sites which are impacted differently by organic and inorganic nutrient loads. This study presents results from two contrasting rivers in the UK, one in an upland, surface water dominated catchment with lower intensity land use and the other a lowland, ground water dominated catchment with higher intensity land use. Three sites within each catchment were chosen to represent an environmental gradient of differing organic and inorganic nutrient concentrations. Seasonal bioassays were performed to determine the relative bioavailability of different organic nitrogen and phosphorus compounds at the six sites. Samples were assessed for the productivity of each nutrient treatment (expressed as chlorophyll a concentration) and algal community assemblages were examined at different levels of detail using pigment analysis, microscopy and DNA methods. Results indicate that bioavailability, algal productivity and composition differ among sites, with consistent patterns in nutrient limitation within sites occurring over time. This work will provide information on the role of organic nutrients in structuring the productivity and composition of riverine algal communities.

ARTIFICIAL LIGHT AT NIGHT AFFECTS STRUCTURAL AND FUNCTIONAL ASPECTS OF MACROINVERTEBRATE COMMUNITIES

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The area of the Earth's surface exposed to artificial light at night (ALAN) is increasing worldwide. The use of ALAN is widespread near freshwater bodies, where human populations are concentrated. Light intensities as low as 10-3 lux can reduce macroinvertebrate drift in streams. Light intensities at the water surface of ALAN-exposed streams can exceed these observed thresholds, potentially disrupting diel behaviour patterns in organisms regulated by natural light/dark cycles. We compared density as well as taxonomic and functional composition of macroinvertebrate communities exposed to ALAN (ca. 20 lux) with control communities experiencing natural light/dark cycles in a set of sub-Alpine streamside flumes. We additionally tested whether control and treatment communities were able to return to similar conditions one week after the ALAN treatment was terminated.
There was a 3-fold increase in macroinvertebrate density in ALAN-treated flumes after one week in spring that we attributed to inhibited drift of Baetis spp. and Chironomidae. In contrast, filterers density decreased under ALAN. These effects persisted one week after ALAN was removed. There was no effect of ALAN in autumn, when densities and drift rates were much higher, suggesting that the found effects are dependent on season and phenology.
Given the important ecological role of macroinvertebrates in streams, results from our study indicate that functionality of freshwater ecosystems can be substantially impacted by ALAN. Typically, exposure to ALAN is for long periods of time, and the effect of ALAN might be more pronounced than found for the short-term exposure studied here.

PHISH-DB - PORTUGUESE HISTORICAL FISH SPECIES DATABASE

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Fish communities are a sensitive part of fluvial ecosystems since they belong to the upper part of the trophic chain and require different habitats and large connected areas for the completion of their life cycle. Migratory fish species, especially diadromous fish, are excellent biotic indicators of the longitudinal connectivity in rivers and may provide important insights into decision making regarding connectivity. However, the Portuguese rivers are impounded by 166 large dams and more than 3000 small weirs, which led to long-distance migratory fish species have long disappeared from many river catchments and responses to connectivity losses based on present-day fish assemblages are generally weak. Historical information about species occurrence may help to model the pre-barrier potential distribution of fish species. This is crucial to define reference conditions and to establish benchmarks for river restoration, and also to study the legacies of previous human interventions into riverine landscapes and the consequences of past disturbances. In this work a large number of historical documents were consulted (46), where records occur in 27 different major river basins, covering the entire Portuguese inland territory, with information on about 14 freshwater fish species or taxonomical groups. PHISH-DB contains 1354 entries ranging from 1066 to 1980, being the 19th century the most represented one (53,8%). This unique historical database and the developed methodological approach, to our knowledge the first of its kind in Portugal, may be useful for multiple research areas and will be helpful to improve the management and conservation of Portuguese freshwater ecosystems.

SO MANY MIDGE SPECIES FOR A SMALL RIVER?

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Up to 41 species of midges were found in three different sites of a small calcareous stream located in the headwaters of the Saldes river, a tributary of the Llobregat river (NE Spain). Differences in time (spring vs. summer) or among the three stations sampled cannot explain the coexistence of so many taxa possessing similar traits. We explored the coexistence of several species of three genera, which are fairly abundant in the study sites, to know: Eukiefferiella, Rheocricotopus, and the Cricotopus-Orthocladius complex, with 7, 3 and 4 taxa respectively. We looked for associations with microhabitat (substrate) preference and used the OMI method (Outlying Median Index, OMI) to distinguish the niche of different species in relation to the hydraulic characteristics within each site (i.e. sampling 20 small Surber samples per site). Taxa were not clearly associated to particular substrates but hydraulic features better helped to explain the coexistence of taxa with similar ecological requirements, being water velocity and Reynolds number the most important parameters. The global OMI analysis was statistically significant and 8 taxa over 14 presented significant hydraulic marginality. Our results clearly separated the niches of 5 different congeneric species of Eukiefferiella along a gradient of velocity, as well as a couple species within the Cricotopus-Orthocladius complex. Differences in the realised niches of congeneric species could be partially explained by the varying substrate availability in the study sites, leading to small-scale differences in hydraulic conditions.

PIECING TOGETHER THE PUZZLE: ASSESSING HYPORHEIC ECOLOGY IN RIVERS

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We combined different methodologies derived from hydrology, community ecology, and biochemical engineering in order to address the hierarchical interplay between sediment hydrodynamics, community structure and biochemical processes of the hyporheic zone (HZ). We followed the gradual variation in the community composition between the benthic zone (BZ) and HZ at a high-resolution scale in both up-welling and downwelling areas. We found that hydrology determined the vertical distribution of benthic and hyporheic communities (hyporheos). In up-welling areas the upper limit of hyporheos distribution occurred at shallower depths in the sediments than in downwelling areas. Biomass and production of invertebrates, ciliates and flagellates decreased with depth and under UW areas. However, the rate at which this decrease with depth occurred differed significantly with taxonomic group, declining fastest in invertebrates, followed by the ciliates and flagellates. This evidenced that organisms differ in their ability to penetrate into the sediments depending on the biological traits that they possess. Finally, it was not possible to associate the attenuation of nutrients and pollutants with the ecological features of the community or the hydrology. However, the majority of these compounds decreased faster along the upper sediment layers, where communities were more diverse and productive.

BIOGEOCHEMISTRY OF IRON, NITROGEN AND PHOSPHORUS IN A MEROMICTIC LAKE AND ITS FERRUGINOUS SEDIMENTS: LAKE MEDARD, CZECH REPUBLIC

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In freshwater ecosystems, reactive iron (Fe) species fuel a very active elemental cycling largely driven by autotrophic and heterotrophic metabolisms, including obligate and facultative nitrate (NO3-) and ammonium (NH4+) bioutilization. Here we evaluate the relation between geochemical processes and natural populations of iron- and nitrogen-utilizing microorganisms as occurring in Lake Medard (Karlovy Vary, Czech Republic). This lake was a former open lignite mine flooded as part of a major reclamation effort.

In Lake Medard, the oxidative dissolution of sulfur-containing minerals (e.g., pyrite (FeS2)) delivers significant amounts of sulfate, iron, and other heavy metals to the wlacustrine ecosystems, which also has some aeolian input of refractory organic matter (i.e., humites) due to terminal coal mining operations. Geochemical profiles of the water column reveal that the lake is meromictic, with an anoxic hypolimnion characterized by high concentrations of sulfate (up to 21 mM), and divalent [Fe2+] in excess of 100 µM. In the ferruginous bottom waters, the complete reduction of NO3- and manganese (Mn4+, Mn3+) was also observed, together with a general lack of dissolved sulfide.

Our geochemical dataset, together with the distribution of NOx species, suggest that denitrification and dissimilatory nitrate reduction to ammonium on and below the anoxic sediment-water interface is largely driven by iron-dependant chemolithotrophy and marginally by carbon turnover, as evidenced by our chromatographic data. Under such environmental conditions, microbial activity induces the precipitation of partially reduced Fe-bearing minerals with high phosphate (PO43−) adsorption capacity, which maintains a general oligotrophic state on the water body.

SPATIAL DISTRIBUTION AND SEASONAL CHANGES OF WATER MITE ASSEMBLAGES (HYRACHNIDIA) IN DINARIC KARST SPRINGS

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Complex life history traits of water mites, including numerous stages and overlapping life cycles with emergent freshwater insects, make them extremely important components of freshwater fauna in terms of spatial distribution and diversity. Karst springs are particularly important on various ecoscales, housing undiscovered water mite resources. Thus, the aims of this study were to analyze water mite assemblages of Mediterranean and alpine karst springs and their seasonal changes in Croatia. The water mites were represented by 11 genera, decreasing in taxa richness from alpine to Mediterranean springs. Diversity and abundance were significantly higher in alpine springs during fall compared to Mediterranean springs and other seasons. Spatial patterns of water mite assemblages at a regional scale were best explained by water temperature, dissolved oxygen and velocity. Water mite taxa Pseudotorrenticola sp. and Oxus sp. were exclusively found or abundant and positively associated with higher water temperature and velocity, while Aturus sp. and Woolastookia sp. were exclusively recorded in the alpine springs, where oxygen concentrations were significantly higher. Atractides sp., Lebertia sp. and Sperchon sp. were recorded in most springs with domination of the genus Atractides during winter. Regional differences in seasonality of water mite abundances were most likely patterned by emergence of insect crenofauna.

HYDRODYNAMIC HETEROGENEITY KEEPS EPILITHIC BIOFILM DIVERSITY HIGH IN FLUVIAL ECOSYSTEMS

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As predicted by the habitat heterogeneity hypothesis biodiversity is tightly linked to habitat heterogeneity. Structurally complex habitats provide more physical niches for a greater diversity of species or functional traits. Hydrodynamics are important physical characteristics of fluvial ecosystems affecting habitat heterogeneity by temporal and spatial variations of the flow velocity. Previous studies have been restricted to experimental systems, where the highly complex flow fields of fluvial systems cannot be reconstructed to the full extent. In a novel approach we link measurements of small scale flow variability to the diversity of different trophic levels of biofilm communities in fluvial ecosystems. We hypothesize (1) that stream bed heterogeneity alters diversity of biofilms at regional scale (γ- diversity) due to increased differences in community composition between sites (β-diversity) and (2) that increasing resource concentrations masks the effects of flow diversity by reducing its effect on both, β- and γ-diversity. The hypotheses were tested in two mountainous streams (Harz region, Germany) that are comparable in stream bed morphology but differ in the pool of dissolved resources. Irrespective of the concentrations of dissolved resources, bacterial γ-diversity increased with increasing hydrodynamic heterogeneity, which is driven by increased β-diversity in both fluvial ecosystems. Both, the β-diversity of primary producer and protozoan grazer morphotypes increased with increasing hydrodynamic heterogeneity, whereas γ- diversity was not affected. Our results demonstrate that hydrodynamic diversity is an important driver of biodiversity across different trophic levels.

SIZE-BASED INTERACTIONS IN PELAGIC TROPHIC WEBS OF MEDITERRANEAN FRESHWATER AND BRACKISH PONDS

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Body size is a very important trait, related to biological and physiological rates, and a main determinant of the trophic level within the aquatic food web. We collected data of individual body size and abundance along the trophic food web including fish, zooplankton and phytoplankton in 17 Mediterranean freshwater and brackish ponds. We searched for the biotic and abiotic factors influencing size structure across the food web. We hypothesised that the size structure of each trophic group would be influenced by different factors. We expected that fish and zooplankton would be more influenced by size selective predation, and that conductivity would also affect zooplankton size structure since a shift from cladocerans to small zooplankton (e.g. copepods and rotifers) has often been found with increasing salinity concentrations. We also hypothesized that nutrient availability would be the main driver of phytoplankton size structure. Our results showed that both biotic factors (predation) and abiotic factors (productivity and conductivity) influence the size structure of planktonic communities in Mediterranean ponds and that their relative contribution differs among trophic levels. Thus, it is important to take all these factors into account in order to understand the functioning of the trophic web.

UNTANGLING THE EFFECTS OF MULTIPLE HUMAN STRESSORS AND THEIR IMPACTS ON FISH ASSEMBLAGES AT CATCHMENT AND EUROPEAN SCALE – FINDINGS FROM THE MARS PROJECT

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This work addresses human stressors and their impacts on fish assemblages by comparing analyses at pan-European scale with results from Austrian Drava/Mura catchments. Two extensive datasets based on the EFI+ project and the Austrian WFD database are used to untangle the impacts of single and multiple stressors, as well as their interactive effects on riverine fish assemblages.

Geographical distribution and patterns of human stressor variables, belonging to four stressor groups (hydrology, morphology, water quality- and connectivity) are examined, considering single and multiple stressor combinations. To quantify the stressors‘ ecological impact, various fish metrics (based on EFI+/Austrian Fish Index) are analysed by comparing observed and expected response to different stressors, Analytical techniques are following the MARS cookbook for multi-stressor analysis, including Random Forest and Boosted Regression Tree to tackle the complex topic. Stressor-response analysis shows divergent results among different stressor categories/spatial scales, even though a general trend of decreasing ecological integrity with increasing stressor quantity is observed. Fish metrics based on density/species ‘intolerant to water quality degradation’ and ‘intolerant to oxygen depletion” responded best to stressors and combinations. Interactions of stressors were additive, synergistic or antagonistic, emphasizing the importance to consider them in multi-stressor analyses.

Different accuracy and spatial resolution of datasets helps to identify general, pan-European trends over large regions. Complementary, catchment scale analyse provide detailed insights towards multiple stressors restoration. Overall, the knowledge gained in this work provides a basis for advanced investigations in European river basins, supports WFD implementation and helps prioritizing further restoration and management actions.

EFFECTS OF FLOW REGIME ON BENTHIC ALGAE AND MACROINVERTEBRATES - A COMPARISON BETWEEN REGULATED AND UNREGULATED RIVERS

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Natural fluctuations in flow are important for maintaining the ecological integrity of riverine ecosystems. However, the flow regime of many rivers has been modified. We assessed the impact of water chemistry, habitat and streamflow characteristics on macroinvertebrates and benthic algae, comparing 20 regulated with 20 unregulated sites. We found no consistent differences in benthic algal or macroinvertebrate structural and functional traits between regulated and unregulated sites, in spite of differences in flow regime. When regulated and unregulated sites were pooled, overall flow regime affected macroinvertebrate species assemblages, but not indices used for ecosystem status assessment or functional feeding groups. In contrast to macroinvertebrates, overall flow regime did not affect benthic algae. Our results indicate that overall flow regime affected the species pool of macroinvertebrates from which recolonization after extreme events may occur, but not of benthic algae. When individual components of flow regime were analyzed separately, high June (i.e. three months before sampling) flow maxima were associated with low benthic algal taxon richness, presumably due to scouring. Macroinvertebrate taxon richness decreased with lower relative minimum discharges, presumably due to temporary drying of parts of the riverbed. However, recolonization after such extreme events presumably is fast. Generally, macroinvertebrate and benthic algal assemblages were more closely related to water physico-chemical than to hydrological variables. Our results suggest that macroinvertebrate and benthic algal indices commonly used for ecological status assessment are applicable also in regulated rivers.

HABITAT COMPLEXITY AND PREDATION RISK EFFECTS ON COMMUNITY ASSEMBLY IN SMALL STANDING WATERS

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Community assembly in small standing waters is driven by a multitude of factors including habitat complexity and consumptive and non-consumptive effects of predation risk. Increased habitat complexity represents a bottom-up factor that increases the number of available microhabitats and should therefore support higher biodiversity and larger biomass of colonizing invertebrates. The consumptive and non-consumptive effects of predation risk should generally lead to fewer colonizers. However, the joint effects of both factors are virtually unknown. We ran a full-factorial mesocosm colonization experiment with two levels of habitat complexity (present/absent artificial vegetation) crossed with three levels of predation risk (none, caged and free-ranging predators) by late-instar Aeshna larvae in 45-litre containers in summer 2015. The containers were inoculated with zoo- and phytoplankton, left open for colonization by flying insects and other organisms, and the resulting communities were sampled destructively after one month. We determined changes in community composition on multiple trophic levels: periphyton biomass and species composition, phytoplankton biomass and species composition in water column, zooplankton abundance and species composition, and aquatic insect biomass and composition. We observed strong cascading bottom-up effects of increased habitat complexity manifested mainly by higher phytoplankton concentrations, decrease in periphyton biomass, increased biomass of herbivorous insects, and additional effects on size spectra and taxonomic composition. On the other hand, the effects of predation risk were minor or absent. Our results thus suggest that habitat complexity is the primary factor influencing initial phases of colonization of small water bodies.

EFFECT OF NICHE CHARACTERISTICS, DISPERSAL ABILITY AND SITE POSITION WITHIN STREAM NETWORK ON OCCUPANCY FREQUENCY DISTRIBUTION OF STREAM INSECTS

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One approach to examine patterns in the distribution of species in nature is the occupancy frequency distribution (OFD), which can delineate rare and common species. A number of ecological mechanisms have been associated with different forms of OFD. At one extreme end, there are generalists and common species with broad niches and wide regional distribution, that patterns are driven mainly by the dispersal based processes. At another extreme end, there are specialist and rare species with small ecological niches and restricted distribution, those patterns are influenced mainly by niche-related processes. For stream organisms the unimodal right-skewed OFDs are common, implying that most species are very rare. This pattern indicates that the assemblages are under environmental control and are driven by niche-related processes caused by the high environmental variability and geographical isolation of habitats. Beside niche based processes dispersal-related processes may also account for species distribution patterns and predict bimodal OFD in which most species are widespread or extremely restricted. In streams assemblages the bimodal OFD is rare and it can be seen in the case of generalist and widespread species groups. The relative role of niche and dispersal-related processes can be varying depending on the positioning within the stream network and environmental heterogeneity. Furthermore, within the same assemblage the role of niche based and dispersal related processes can have different effect on the distribution pattern of species having different ecological (specialist vs. generalist) or biological (i.e. weak vs. good dispersal ability) traits. We compared the OFD of freshwater insect assemblages between sites having different position within stream networks (streams and rivers) in Hungary. The sampling sites were surveyed twice (spring and late summer) during one year period to determine the seasonal influence. We

deconstructed entire insect assemblages by ecological (niche breath, niche position) and biological traits (dispersal ability) and tested the differences in the form of OFDs between the different ecologically and biologically defined groups separately in running water types and seasons within water types. We found that distribution patterns varied between the subgroups of species having different ecological and biological traits. Generally, the sets of species with marginal niche position, small niche breath and weak dispersal ability showed strongly right-skewed OFDs with dominance of very rare species. The sets of species with non-marginal niche position, large niche breadth and good dispersal ability mainly showed right-skewed OFDs with much variation in occupancy and without the dominance of left-most classes, however in some cases bimodal OFD pattern was detected. We didn't found clear differences in the OFD patterns between sites (streams and rivers) having different position within stream network.

RS04 – Presentation

MAYFLY EMERGENCE PATTERNS: A LONG-TERM STUDY IN TUFA DEPOSITING HABITATS OF DINARIC KARST

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Mayfly emergence patterns and microhabitat preferences were studied in the Plitvice Lakes NP (Croatia) during a nine-year period in two types of karst freshwater habitats: a spring and two tufa barriers, using pyramid-type emergence traps. A total of nine mayfly species were recorded. Highest proportion of collected individuals belonged to the genus Baetis which was recorded at all three study sites, but we were unable to distinguish between two included species (B. rhodani and B. cf. nubecularis). Other numerous recorded species were Paraleptophlebia submarginata, Ephemera danica and Rhithrogena braaschi. Tufa barriers had higher species richness and diversity than the spring but significantly lower population densities. In MDS analysis, the spring separated from tufa barriers. Mayfly assemblages were at all sites dominated by species typical for the rhithral zone, while in tufa barriers, potamal and littoral elements also appeared. In the studied spring, emergence mainly occurred between March and November, where the main trigger for emergence was photoperiod. In tufa barriers, emergence mainly occurred between April and July and was related to the elevated water temperature. Generally, higher abundance of emerging individuals was recorded during the years with higher water discharge. Emergence patterns of some species were in accordance with their typical Central European emergence patterns (e.g. E. danica) while some other showed certain discrepancies (e.g. Rh. braaschi). The highest species richness was recorded on moss, and the highest number of individuals on gravel/tufa. Baetis sp. preferably emerged from gravel/tufa and moss, and Rh. braaschi from vegetation (moss and macrophytes).

ENVIRONMENTAL FACTORS AFFECTING A- AND B-DIVERSITY OF MAYFLY (EPHEMEROPTERA) COMMUNITIES IN A HIERARCHICAL LOTIC SYSTEM

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Mayfly nymphs (Insecta: Ephemeroptera) can be classified into diverse functional groups with typical ecological requirements, and are influenced to a great extent by environmental parameters. In marine and terrestrial systems it has been shown that patterns of species diversity in hierarchical settings follow scale-dependent limitations such as regional species pool, environmental and geographical factors. While diversity patterns can be explained by numerous environmental factors, studies of hierarchical systems in which sampled communities are nested on several scales enable to determine the important factors for each level. We sampled multiple lotic habitats throughout Israel in a three-scale hierarchical setup. Mayfly nymphs were collected, identified and counted, and α- and β-diversity components were calculated for each community. Environmental variables on different scales were measured in the field or obtained from published datasets. The most important environmental predictors of diversity components were selected using multivariate models. We describe the structure of mayfly communities on three levels, and link it to the relevant environmental factors for each of them. Our results highlight the importance of studying species occurrence and community structure based on relevant environmental predictors, in particular regional species pool. Because freshwater ecosystems in developed countries are continuously threatened by multiple stressors, tracking relevant environmental changes and the resulting biological responses is essential for sustainable management.

POST-DISTURBANCE CHANGES OF MACROINVERTEBRATE ASSEMBLAGES DOWNSTREAM OF A LARGE DAM IN THE DINARIC KARST RIVER DOBRA (CROATIA)

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Dinaric Mountains' rivers represent one of the most important hotspots of the European freshwater biodiversity. However, large dams continue to be built and many more are planned on these rivers, despite the scarce knowledge about the dam impact on aquatic biodiversity in this area. In 2010 a new large dam (52.5 m high) on the karst river Dobra (Croatia) was finished and closed. Temporal changes of macroinvertebrate assemblages were examined at the site located 460 m downstream of the dam in the period before (2007-2008) and after the dam closure (2010-2015). Replicate samples of macroinvertebrates were collected in mosses and on stony substrate using hand net. The new dam caused drastic short term changes in water quality, and permanent changes of temperature and flow regime. Mosses and stony substrate significantly differed in macroinvertebrate assemblages in both, pre- and post-disturbance periods. Dam closure represented the most intensive disturbance event, which caused drastic change of macroinvertebrate assemblage structure in both microhabitat types during the first two post-disturbance years: reduction of density of dominant groups such as Amphipoda, Gastropoda and dominant insects groups (Coleoptera, Ephemeroptera and Trichoptera) as well as the drastic increase of Chironomidae density, followed by density recovery of all previous groups in the second year. Samples from 2015 had the highest similarity with pre-disturbance assemblages for both microhabitat types implying partly recovered macroinvertebrate assemblages five years after dam closure. By comparing pre- and post-disturbance data, this study increases our understanding of basic ecological response to damming.

IS WATER QUALITY THE PRIMORDIAL CAUSE FOR THE ABSENCE OF INTOLERANT AQUATIC INSECT SPECIES IN URBAN STREAMS?

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Streams draining urban areas are affected by ecological degradation, revealed by symptoms as flashier hydrographs, elevated concentrations of nutrients and contaminants, altered channel morphology, and reduced biotic richness, with increased dominance of tolerant species. The urban stream syndrome is a consequence of multiple, co-occurring and interacting stressors difficult to disentangle and assess individually. We assessed the effects of water and food from two origins (urban vs. forest stream) on the consumption and survival of nymphs of highly intolerant (IBMWP score 10) aquatic insects of the genera Leuctra (Ephemeroptera) and Sericostoma (Trichoptera). Larvae were kept in water, either from an urban or a forest stream and fed with alder leaves, previously incubated either in the urban or in the forest stream water, in a total of four treatments. Consumption rates of urban food were higher than consumption rates of control food, and higher in the urban than in the forest stream water. In the case of the Plecoptera, the highest consumption rates resulted in the highest increase in body mass and earlier eclosion, suggesting a compensatory feeding mechanism. This may be due to deficient microbial colonization of the leaves incubated in urban stream water resulting in lower food-value. However, a larger experimental set and longer period trial must be carried out in order to disentangle the effects of water quality from other factors potentially causing the lack of intolerant aquatic insect species in urban streams.

CHANGING PATTERNS IN THE LITTORAL ECOTONE AND POTENTIAL FACTORS IN ITS DECLINE IN A NORTHERN ENGLISH LAKE OVER A HUNDRED-YEAR PERSPECTIVE

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Reedbed habitats dominated by stands of Common reed, Phragmites australis, are key areas of the littoral ecotone of lakes. During the last few decades, reedbeds have shown a significant decline throughout Europe, a trend that has also been observed on a local scale in lakes of the English Lake District.

Reedbeds provide a number of ecosystem services: microhabitats for algae and invertebrates, which are an important food source for other invertebrates as well as fish, mammals and water birds; provide physical protection of lake shores; help in carbon sequestration; have a role in nutrient cycling; and are a buffer between the terrestrial and the aquatic habitats. In addition, many of the species found living in, or associated with them, are of national and international importance.

The decline of these habitats has been attributed to many different factors such as: changes in land use; shoreline development; eutrophication; artificial changes in water levels; extreme hydrological events; and climate change. The results of some of these declines may be a loss of biodiversity as well as an impact on the water quality.

The aim of this paper is to verify and quantify reedbed retreat at Esthwaite Water (NW of England) over a hundred-year time-scale. The decline is analysed using an interdisciplinary approach, taking into account different scales of land use changes, as well as supplementary biological and physical data from the lake catchment. These results are focused on a local scale but contribute to a wider European discussion on the reedbed retreat itself.

DEGRADATION OF SMALL LOWLAND STREAM IN HUMAN-DOMINATED LANDSCAPE

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Stream ecosystems are controlled mainly by morphological, hydrological, and physico-chemical parameters. These attributes directly affect the quantity and quality of available habitats for fish and invertebrates. Benthic macroinvertebrates are often used as indicators of the water and habitat quality. The aim of our study was assessing degradation of small lowland stream using benthic macroinvertebrates and physicochemical parameters of water. The impact of culverts, water pollution, as well as using salt and sand for winter road maintenance on the invertebrate fauna was examined. We hypothesized that the benthic invertebrates inhabiting the modified sites would differ significantly from those at a non-transformed natural sites. The sampling sites were located in two small streams (one with and one without anthropogenic changes) in the San River basin. Benthic samples were collected during seasonality, at five sites. Culverts disrupted the natural balance between deposition and erosion, with the former dominating above the culvert and the latter dominating below the culvert. Changes in channel of the stream were also associated with the accumulation of sand and fine sediments. Siltation of the substrate decreased the variety of the habitats, and the community of invertebrates became less diverse. Furthermore, the water pollution worsen the living conditions of natural communities of invertebrate fauna, especially invertebrates that require good water quality, and associated with well oxygenated water like stoneflies, caddisflies and some gammarids. Anthropogenic factors caused a change in water chemistry and altered the grain size of the substrate, which directly affected the qualitative and quantitative composition of the macrozoobenthos.

THE EFFECTS OF DOM-SOURCES FROM AGRICULTURAL LAND USE ON MICROBIAL ACTIVITY IN RIVERINE SEDIMENTS

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Agriculture is the dominant land use form in Lower Austria, covering more than 46 % of the total area. Agriculture delivers significant amounts of dissolved organic matter (DOM) to streams, thereby changing basic processes at the water-sediment interface and affecting the ecological state of the stream ecosystem. The aim of the project is to investigate the influence of agricultural land use on the quantity and quality of DOM inputs to streams and to clarify the effects of this DOM inputs on the aquatic carbon cycling in stream ecosystems. Via in-door flume experiments, we investigate the short-term effects of different DOM sources (amongst others, manure, leaves, soil from pasture and crop fields) on the growth and the activity of benthic microorganisms, the benthic respiration and the activity of extracellular enzymes. The DOM sources are analyzed as to their fluorescence (e.g. humification index, fluorescence index, freshness index, redox index via Excitation-Emission-Matrices) and absorbance characteristics (e.g. SUVA254, spectral slope for 275–295 nm), dissolved inorganic nutrients (NO3-N, NO2-N, NH4-N, PO4-P), DON concentrations and amino acids.

DEALING WITH FRESHWATER NETWORKS – THE RIVER NETWORK TOOLKIT

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Freshwater ecosystems are amongst the most endangered environments worldwide. Using and combining detailed landscape and river network data, though challenging, is fundamental for an effective research of freshwater ecosystems. The dendritic nature of river networks has implications in processes at population and community-level. Given the longitudinal dimension of river networks, processes occurring at a segment are dependent on processes occurring in all upstream segments. There is a respective drainage area for every segment where inputs from the surrounding landscape influence processes occurring at the segment, and those downstream. Focusing on multiple scales while integrating the growing number of layers of digital information with dendritic river networks has led to bulky processing times and demanding hardware requirements. Common use geographic information systems (GIS) have numerous limitations when performing summarisations or automatized calculations along directional and hierarchical freshwater networks. The River Network Toolkit (RivTool) was developed to effortlessly deal with these challenges. This user-friendly software is time effective even with large datasets and has a set of ready to use libraries for the European continent. Regardless of the extension and complexity of a freshwater network, this innovative software reduces the time required for extracting information for these ecosystems and facilitates the use of multiple types of data. Thus, it can decisively contribute to enhance scientific accurateness when producing or improving knowledge on large scale patterns and processes in river networks.

A TIMELY LOOK AT EFFECTS OF AGRICULTURE ON FLUVIAL DOM: THE ROLE OF HYDROLOGY. AGRHYDROM, 2ND YOUNG COLLABORATIVE PROJECT FROM THE IBERIAN ASSOCIATION OF LIMNOLOGY

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The study of ecological processes requires a broad spatial coverage in a consistent time frame and methodology, which makes Coordinated Distributed Experiments a valuable tool for the study of freshwater ecosystems. In this context the Iberian Association of Limnology (AIL) launched its second call for Collaborative Projects among young researchers in 2015 with the double aim of funding original research and promoting networking among the young researchers of the association. Here, we present the awarded project, AGRHYDROM: A timely look at effects of agriculture on fluvial dissolved organic matter: the role of hydrology.

Owing to the current scenario of global change, which predicts an increase in both flow intermittency and agriculture practices, the AGRHYDROM project aims to examine the combined effect of agriculture and seasonal hydrology fluctuations on nutrients and dissolved

organic matter (DOM) quantity, composition and bioavailability in streams across the Iberian Peninsula and Europe. We will determine the concentration of dissolved organic carbon, dissolved organic nitrogen and nutrients in 3 phases of the hydrological cycle: base flow phase, contraction and expansion phases. Additionally, we will analyze DOM composition by spectroscopic measurements (fluorescence and absorbance) and bioavailability to infer the implications of DOM changes due to agriculture and seasonal hydrology on carbon cycling and river functioning.

ECO-PHYSIOLOGICAL CHARACTERIZATION OF THE MACROINVERTERBATE COMMUNITIES OF A VERY DISTURBED URBAN STREAM (RIO TINTO, PORTUGAL): HOW THEY SURVIVE?

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The Water Framework Directive (DQA-2000/60/EC) establishes as its main objective the achievement of a good ecological quality of all inland surface waters and groundwater, and introduces the concept of „ ecological status „ of an ecosystem , which includes the study of a wide range of parameters and factors for determining the „ health „ system „.

This work, carried out within a project which main objective is the rehabilitation of a small watercourse in high degree of ecological degradation, aims to make the study of benthic macroinvertebrate communities and some parameters related to the ecological state of Rio Tinto (Douro watershed) in order to determine the main sources of pollution and to propose measures for its rehabilitation.

This study compare results (metrics and functional structure) of samples of the benthic macroinvertebrate communities collected at some sampling sites along the river from december 2015 to march 2017 and values of some hydro-morphological, physical and chemical parameters.

The results indicate that in spite of the high degree of environmental disturbance that exists throughout the river, it is possible to find a relatively diverse and stable benthic macroinvertebrate community with organisms that due to their ecological and physiological characteristics can survive in a very disturbed environment

KEY DRIVERS OF GOOD ECOLOGICAL STATUS IN THE VLTAVA RIVER BASIN

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General principles of the relationships between biological communities and other components of the aquatic ecosystem are known; however, for proposing measures to improve the ecological status, detailed knowledge of ecosystem functioning is required.
Monitoring the physico-chemical parameters is among the largest monitoring that is performed by Povodí Vltavy, State Enterprise. Hydromorphological parameters show that their effect on biological components is substantial, but it is very difficult to distinguish it from the impact of water quality because hydromorphologically affected streams (large rivers, streams in agricultural catchments) mostly have an impaired water quality. Specific pollutants include a range of substances and there is not yet enough data available to analyse their specific effects on the biological components.
Currently the biological components are monitored at a total of 324 monitoring sites and at all sites the physico-chemical parameters are simultaneously monitored. The results are presented on the basis of evaluation of ecological status of the biological components macroinvertebrates, phytobenthos and fish in the period 2008-2015. The values of different biological metrics and structure of these communities were analysed to find relationships with selected physical - chemical parameters - BOD5, dissolved oxygen, nitrogen and phosphorus compounds, together with the added parameter chlorophyll-a. Typological characteristics of catchment size and altitude have been taken into account. The influence of the presence of ponds in the catchment was studied in more detailed.
The results of the analyses were compared with the limits of good status of physico-chemical parameters defined in the official national methodology.

A JOINT SPECIES DISTRIBUTION MODEL FOR MACROPHYTES IN SWISS RIVERS

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We use a large set of macrophyte and bryophyte sampling data from federal and cantonal survey programs to derive joint species distribution models that describe the occurrences of macrophyte and bryophyte taxa and their dependence on natural and human influence factors. The models consider the most important and spatially available influence factors, such as shading, river slope, discharge, water depth, water temperature, river morphology, and nutrient concentration as fixed effects, and additional, unavailable or unidentified influence factors as random effects. We formulate and test a sequence of models of increasing complexity to learn about the effect of including additional model elements. All models belong to the class of hierarchical, generalized linear models and their parameters and states are estimated by Bayesian inference. Posterior diagnostics allow us to compare the quality of fit and, in a cross-validation setup, to estimate the predictive capabilities of the different models. The models and Bayesian inference are implemented using the Hamiltonian Monte Carlo (HMC) approach to Markov Chain Monte Carlo (MCMC) sampling of posteriors, as implemented in the software STAN (http://www.mc-stan.org) and accessed through the R package rstan (https://cran.r-project.org/web/packages/rstan/rstan.pdf). Despite considerable scatter in the data due to random effects, we identify key influence factors and different behavior of different macrophyte growth forms that can be well represented by the hierarchical model. The model is intended to contribute to the understanding of the observed structure of macrophyte communities in Swiss rivers as well as to support river management by probabilistically predicting the effect of restoration measures.

ESTIMATING LAKE WATER QUALITY FROM MODELLED NUTRIENT LOADING: APPLICATION OF SIMPLE MODELS

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Eutrophication is a major cause of lake ecosystem alteration. For the management of lakes, it is crucial to link water quality to land use and human pressures. This study presents an attempt to relate measured physico-chemical parameters in up to 200 lakes in France, to nutrient loading from their watershed predicted by the 'Nutting' model. Nutting estimates annual nitrogen and phosphorus export at the reach scale from nutrient diffuse and point sources. Model outputs were aggregated at lake-catchment scale and annual average loads were related to lake nutrient concentrations using Vollenweider type input-output models. It appeared that these models did not perform better than linear models using nutrient input and average lake depth or water residence time as predictors. Moreover, a similar linear model was also able to predict well mean lake water transparency. A possible application of the calibrated models is the prediction of water quality in lakes where no measurement is available. The models can also be used to estimate lake physico-chemical reference conditions from reference nutrient concentrations in tributaries. However, prediction intervals of such models are large and comparison with environmental standards can be difficult. In order to reduce uncertainty, more elaborated models are needed which take into account intra-annual variations in nutrient input or lake characteristics.

EXPLORATION OF OYSTER (CRASSOSTREA TULIPA) FISHERY IN A COASTAL WETLAND IN GHANA: UTILIZATION AND ADAPTATIONS TO CLIMATE CHANGE

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The utilization of ‚invisible'' marine resources like the West African oyster Crassostrea tulipa are capable of reducing food insecurity and malnutrition and providing income to fishers in Ghana. Loss of coastal wetlands to climate change will directly have impacts on food, water and livelihood security. Many artisanal fisheries stocks and the livelihoods of those who make their living from fishing are in decline, and these declines are exacerbated by uncertainties associated with increased climate variability and change. This paper examines how oyster fishers in the Whin Estuary in western Ghana (longitude 10 48W and latitude 40 56N) utilize fish products of C. tulipa and how they perceive and adapt to indicators of climate change. Mixed method involving participatory approaches such as focus group discussions, individual and key informant interviews using a checklist, semi structured questionnaire and interview guide respectively. Thirty oyster fishers were purposively sampled and interviewed through snowball technique to identify respondents. Moisture, crude protein, crude fat, minerals and ash were determined at the Technology Village of the University of Cape Coast following the procedures of the Official Analytical Association of Chemist. The research showed that the mean percentage nutritional values determined for its meat were 43.28 ± 0.35 protein, 8.67 ± 0.24 % carbohydrate, 0.03 ± 0.001mg of Iron, 22.98 ± 0.78 calcium, 10.89 ± 2.18 % ash and 79.03 ± 0.97 % moisture. The shells are used in manufacturing of poultry feed, powder for demarcation of fields and paint for building. Women adapt differently to climate indices and also have rich indigenous knowledge in the prediction of these indicators.
Keywords: Oyster, Climate change, vulnerability, adaptation

DETERMINATION OF FISH FOOD RELATIONSHIPS IN BAFRA BALIK LAKES (DELTA KIZILIRMAK, TURKEY)

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To figure out feeding habits is extremly important to understand an ecosystem. Priorly years fish feeding habits were only determined by using stomach content analysis. However nitrogene isotop analysis were used addition to stomach analysis in last decades. This study investigates trophic relations in Bafra Balık Lakes that located in Delta Kızılırmak which is in Blacksea Basin. Nitrogene isotop analysis is used first time with this study in Turkey plus to stomach content analysis. Carassius gibelio, Cyprinus carpio, Sander lucioperca, Vimba vimba and Gasterosteus aculeatus were estimated from 103 indivudials with 15N in muscle were ‰6.5; 6.7; 9.3; 9.5; 9.7 respectively. The data obtained from the stomach content analysis were also parallel to the data obtained with the nitrogen isotope analysis in muscle.

DRIVERS OF IMPAIRED ECOLOGICAL FUNCTIONING IN CONSTRUCTED DELTA LAKES, A CASE STUDY ON LAKE MARKERMEER IN THE RHINE DELTA.

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Growing cities in densely populated delta areas around the globe require year-round access to sufficient fresh water and protection against flood events from the river or sea. Therefore, water storage and flood protection is regulated by dams and dykes, resulting in the creation of artificial lakes in these deltas. Besides the main purposes for which these lakes were constructed, they also provide a wide range of other ecosystem services like for example recreation or food production. Moreover, these lakes can be considered to be important wetland habitats, characterized by shallow fresh waters with soft sediments, with a high potential for ecological developments. However, in reality the water levels and shorelines are predominantly artificial, and the water quality is often poor due to pollution and changed hydrology. This is also the case in lake Markermeer, a large and shallow reservoir created in the Rhine delta in the central part of the Netherlands. After closure of the last dyke in 1975, the lake became strongly influenced by habitat modifications, resuspension of fine sediments and changed nutrient dynamics. This has resulted in an ecological collapse during the past decades. Here, we will present results of experiments and field monitoring, studying the influence of biotic and a-biotic benthic processes on productivity and food-web structure in lake Marken. By analyzing the main drivers underlying the observed changes in relation to the negative impacts, essential insight is generated to effectively restore the ecological functioning of ecologically impaired constructed delta lakes.

THE PHENOLOGICAL RESPONSE OF TROPICAL WETLAND PLANTS ON HYDROCLIMATOLOGICAL VARIABILITY IN LISBRAN, COLOMBIA

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Phenology is the science of repeating cycles within species. Responding to hydroclimatological factors phenology can be seen as an indicator for hydrological and climatic variations. Plant phenology has gained importance in global research in the last decades, especially in temperate regions. However, phenological research in tropical regions is still scarce. Within the "Investigation Group on Ecology, Engineering and Society (EIS)" phenological investigations were firstly implemented in a remote wetland in Lisbran, Colombia, with the help of digital cameras. The group EIS is incorporated in the Universidad Tecnológica de Pereira (UTP) and conducts research projects, dealing with important local and environmental issues. The study presented in this paper was conducted in the framework of EIS. The objective of my study was to correlate the hydroclimatological factors precipitation, water level and radiation to vegetation phenology in a Colombian wetland and to investigate whether the fluctuating supply of hydroclimatological factors influences vegetation phenology, while analyzing which other parameters might affect this correlation. To investigate the relation between the abiotic factors and phenology I processed the images resulting from the near surface sensor derived investigations in five defined areas of interest, comprising three vegetation types, with the help of the Matlab extension "Phenocam Image Processor V1.1" and calculated the "Green Chromatic Coordinate (GCC)". The GCC is an indicator for plant phenology and can directly be correlated to hydroclimatological measurement data, which I retrieved from a weather station in the study area. Thereby, I was able to calculate Pearson's correlation coefficient to express the independency between plant phenological data and hydroclimatological data. Analyzing the data, various factors which were assumed to have influenced the research results were also taken into account; I considered e. g. influences of species type, influences of dry and rainy periods and territorial influences on the results of the study. The investigations focused on two periods in 2015 (3.02 - 23.04 and 02.09 - 04.11). The aim was to take a first step into the direction of phenogical-sensor derived investigations in Colombia and to gain an understanding on how plant phenology and hydroclimatology is interrelated in a tropical, moist surrounding, in which phenological cycles are often not obvious.

TESTATE AMOEBAE INHABITING MINEROTROPHIC MIRES: EXPLORING DIVERSITY PATTERNS ON A SMALL SPATIAL SCALE

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Testate amoebae represent a group of unicellular shelled organisms which are commonly studied in peatland ecosystems. So far, the main part of ecological research was focused mostly on bogs where these organisms are regularly used as a proxy in paleoecological studies. In contrast, ecology of testate amoebae in minerotrophic mires remains rather unexplored. In this study, testate amoeba assemblages were examined at two fen sites differing in mineral richness and moss layer composition. At each study site 20 moss-dominated patches were randomly chosen for sample collection and several environmental variables were tested for their potential effect on testate amoeba species composition. In the course of sample analysis, empty shells and living individuals were distinguished to quantify the effect of empty shells on diversity patterns. In terms of community composition, dominance of Sphagnum or brown mosses was the main predictor of testate amoeba composition in a rich (Sphagnum) fen. Nonetheless, differences in species composition among samples from solely brown-mosses collected at a calcareous fen were also observed. In general, brown mosses harbored higher number of testate species, though having much lower numbers of living individuals as compared to Sphagnum. Despite the fact that distinguishing between empty and living shells is not a common practice in testate amoeba research, it proved that at least in fen habitats the empty shells included in community description might lead to shifts in species composition as well as inaccurate interpretation of species preferences towards certain environmental factors. Supported by the Czech Science Foundation (project no. P505/16-03881S).

MONITORING A RECENT CREATED MEDITERRANEAN COASTAL LAGOON: CHANGES IN PHYSICOCHEMICAL CHARACTERISTICS AND ZOOPLANKTON SUCCESSION

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Coastal lagoons are not only important ecological systems but also provide multiple goods and services to society. The overexploitation of these goods and services has placed these systems under a severe anthropogenic stress. In recent years, some restoration measures are taken to mitigate these negative effects. This study aims to monitor the physicochemical characteristics of water and the zooplankton community succession in a small Mediterranean coastal lagoon created in October 2015. The hydrology of the lagoon is dominated by the superficial aquifer inflow, which is characterized by both seawater influence and freshwater from the mouth of a dry riverbed. Preliminary results showed that after 5 months of its creation characeans covered almost the half of the lagoon basin accompanied by dense patches of Ruppia maritima. Water conductivity increased progressively from 7.7 in November 2015 to 13.9 mS cm-1 in October 2016. pH was maintained around 8 increasing to 10 in late spring when primary productivity increased. The oxygen concentration was always over 100 % of saturation. Water chlorophyll a concentrations varied between 4.2 and 6.9 µg L-1 being low in summer when the biomass of the rooted macrophytes was high. Zooplankton community in the early phases of the succession was dominated by the copepod Diacyclops bicuspidatus odessanus and by the rotifer Brachionus plicatilis, increasing the richness from 2 to 7 taxons along the succession process. This increase was mainly due to the appearance of two rotifers, Hexarthra fennica and Brachionus quadridentatus and one branchiopod, Alona rectangula.

DEVELOPMENT AND FIELD VALIDATION OF A MODEL ASSESSING NUTRIENT RISK TO GROUNDWATER DEPENDENT WETLANDS IN IRELAND

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Groundwater dependent wetlands (GWDWs) provide essential ecosystem services such as maintaining ecological balance through elemental cycling and nutrient retention. Protecting the ecosystem functioning of GWDWs forms an implicit component of the EU Water Framework Directive. The functioning of these systems can be detrimentally impacted through excess loadings of nutrient-enriched water. In order to assess the potential risk of anthropogenic N inputs to GWDWs, a model based on a Source-Pathway-Receptor (S-P-R) approach using available datasets and GIS software, was developed for Irish GWDWs. A subsequent field characterisation and sampling regime at twelve GWDW sites was carried out between spring 2015 and winter 2016, in order to validate the risk model and to examine the importance of nutrient loadings, attenuation processes and the role of nutrient cycling within the system when assessing impacts on GWDW receptors. Predicted nitrate (NO3-N) concentrations, based on the model ranged between 0.29 and 27.15 mgL-1. In comparison, average NO3-N concentrations ±SE measured at the GWDW sites ranged between 0.09 ± 0.02 and 2.5 ± 0.74 mgL-1. Predicted NO3-N concentrations from the model explained 65.7% (r2=0.66) of the variation in field NO3-N concentrations. The results indicated that the model provided reliable information which highlights the potential risk posed to GWDWs from N inputs. In addition, field characterisation indicated high heterogeneity between the sites studied, and highlighted the importance of the S-P-R approach when assessing risk of nutrient loading to GWDWs. This demonstrated that a more integrated understanding of pathways provides valuable insights into natural processes influencing GWDW status.

IDENTIFICATION OF NITROGEN POLLUTION SOURCES IN THE DOÑANA WETLANDS (SOUTHWESTERN SPAIN) USING STABLE ISOTOPES

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Nitrogen pollution has been recognized as one of the most important threats to the Doñana wetland (southwestern Spain) due to increasing anthropogenic pressure in the watershed during the last decades. Diffuse (agriculture) and point pollution (urban and agricultural wastewaters) are both important nitrogen sources to the streams entering the Doñana marsh. However, little is known about the relative contribution of each of these sources to nitrogen pollution. The aim of this study is to give more insight to the origin of nitrogen inputs in the Doñana marsh and entry streams. We measured stable isotopes of nitrogen (δ15N) to identifying the source of nitrogen entering the ecosystem. We sampled two different emergent aquatic plants as indicator species: alkali bulrush (Bolboschoenus maritimus) and southern cattail (Typha domingensis). Samples were collected during the spring of 2013, 2015 and 2016 from sites covering the entire Doñana marshland and the network of entry streams. The spatial analyses revealed a high variability between sites. In general, we found higher δ15N values in areas closer to point and diffuse anthropogenic sources such as the entry streams, but also in nesting areas for colonial waterbirds. Lower values were mostly found in the middle of the marsh far from pollution points. The isotopic results together with results of nitrogen concentrations and land use cover information provide the first broad spatial overview of spatial and temporal variability in nitrogen pollution in Doñana and help to identify the most relevant sources.

POST-MINING CALCAREOUS SEEPAGES AS SURROGATE HABITATS FOR AQUATIC MACROINVERTEBRATE BIOTA OF VANISHING CALCAREOUS SPRING FENS

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Although the temporal stability of environmental conditions in springs is generally known, it remains nearly completely unexplored by direct measurements and statistical approaches. In this study, we want to explore the variation of temperature fluctuations in the Western Carpathian spring fens on regional and within-site scales and to test its influence on the spring fen assemblages. In accordance with the general assumption that the absence of temporal variation favours specialization, we also assume that the environmental stability in springs may favour specialists over generalists. From April to November, we continuously recorded water temperature at 44 perennial spring fens by two dataloggers (Hobo Water Temp Pro v2) installed at each site. One datalogger was placed in the flowing-water mesohabitat and the other in the standing-water mesohabitat which is expected to be more influenced by warming up during summer. First results indicate considerable differences in temperature fluctuations among individual spring fens, apparently associated with topography and physicochemical characteristics of sites. Variation in temperature stability has also been recorded on the within-site scale, where the temperature stability seems to be higher in the flowing-water- than in the standing-water mesohabitat. The data on environmental stability can provide an important indication of the succession triggered by global warming and they are fundamental to make predictions about the resilience of these highly threatened systems and communities.

The study is financially supported by a grant P505/16-03881S.

ASSESSMENT OF ECOLOGICAL QUALITY OF TWO COASTAL LAGOONS (BALIK LAKE AND UZUNGÖL) FROM KIZILIRMAK DELTA WITH A COMBINATION OF SUB

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Coastal lagoons have a great instability due to their location in the transitional zone between land and adjacent sea. In coastal lagoons human pressures such as dredging, recreation, domestic and industrial effluents have produced hydro- morphological modifications which affect water quality. Biological components have also been subjected to human activity. Consequently, ecological quality of lagoons has been influenced by many stressors, e.g. terrestrial runoff, nutrient loadings, depth and turbidity.

The ecological quality of coastal lagoons has been mainly assessed using different indices based on abiotic and biotic variables. Trophic status is usually evaluated with nitrogen, phosphorus and chlorophyll-a. After the WFD/ 2000/60/EC was enforced in the European Union, biological components e.g. macrophytes became key elements for assessing the ecological quality of coastal lagoons.

Balık Lake and Uzungöl is considered as one of the most important lagoons of Kızılırmak Delta complex formed by the deposits of Kızılırmak river. The selected studied areas are highly diverse ecosystems, protected by national legislation and included in the Ramsar site of Turkey as priority habitat types for conservation.

Two coastal lagoons (Balık Lake and Uzungöl) of Kızılırmak Delta subjected to different human pressures were monitored over a one year period for their biotic (submerged macrophytes abundance and coverage) and abiotic features (TP, TN, TDS, turbidity, chlorophyll a, depth). Four ecological indices based on water quality parameters (TSI-Chl-a, TSI-TP) and submerged macrophytes (ESMI, sEQRleafpacs) were applied to assess the ecological status of studied lagoons under natural conditions. Trophic status of Balık Lake and Uzungöl classified as eutrophic based on TSI-Chl-a and TSI-TP scores. The water quality scores did not showed significant differences between lagoons. By contrast ESMI, sEQRleafpacs macrophytes indices showed significant differences among lagoons. The calculation of ESMI and sEQRleafpacs indicated bad/poor (0.04/0.28) and good (0.59/0.64) trophic status for Uzungöl and Balık Lake respectively.

MIGRATING WATERBUGS (HETEROPTERA) TRANSFER N-3 POLYUNSATURATED FATTY ACIDS FROM WATER TO LAND IN TEMPERATE ECOREGIONS

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Freshwater bodies are known to be a main source of essential long-chain n-3 polyunsaturated fatty acids (PUFA) which are primarily synthesized by microalgae and transferred along food chains to terrestrial consumers. Aquatic insects comprise a significant part in transfer of the essential PUFA from water to land. However, quantitative data for PUFA contents are available for mostly lotic insects, while insect taxa, which are characteristic for wetlands and lentic water bodies, such as aquatic Heteroptera, are still unstudied in respect of their fatty acid composition and contents. We studied waterbug taxa (Heteroptera) inhabiting ecoregions of temperate climate (Siberia, Russia): steppe, forest-steppe, hemiboreal forest and montane coniferous forest. Representatives of Naucoridae, Notonectidae and Corixidae families were generally dominant in these ecoregions, having the maximum biomass in steppe. We showed that habitat (ecoregion) explained a major part in variability of fatty acid composition of Notonectidae and Gerridae, but not Corixidae. In turn, life stage mostly determined biochemical composition of the only Naucoridae species. Waterbug families significantly differed in contents of the essential PUFA per a mass unit. Corixid species had the highest content of the PUFA among the studied waterbugs and other aquatic insect orders for which quantitative data are available. Hence, corixids appear to be an important vector for water-land transfer of the essential biochemical compounds, especially in steppe ecoregions with numerous ephemeral water bodies.

TEMPORAL FIELD WETLANDS AS BIODIVERSITY HOT SPOTS IN AGRICULTURAL LANDSCAPE IN THE CZECH REPUBLIC

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Periodically flooded ephemeral pools on arable soil are overlooked endangered habitats which serve as refuge for many wetland organisms within mostly homogenous agricultural landscape. In the Czech Republic, these habitats are especially in lowlands critical for the survival of more endangered and protected plant and animal species, which are often bound to open and shallow, early successional stage of aquatic biotopes with unvegetated substrates and without fish. The research of these habitats revealed information about the composition of assemblages and distribution of interesting plants, aquatic invertebrates, amphibians and wetland birds. Especially large branchiopods (Branchiopoda: Anostraca, Notostraca, Spinicaudata) and some waders (Aves: Charadriiformes) are there flagship species, while populations of some of them are the most abundant in field wetlands within the country. Unfortunately, these habitats are very endangered especially by field drainages, filling of field depressions with soil, ploughing absence or using of chemicals. Moreover, it is usually not possible to protect them by site protection, since they are located on arable soil and require very specific management, including conservation of water regime in combination with regular disturbances, such as ploughing. Further research targeted on effective conservation and suitable management of these unique refuges is necessary.

AN EVALUATION OF THE ZOOPLANKTONIC ORGANISMS WITH ECOLOGICAL VARIABLES IN KOCAÇAY RIVER BASIN

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To understand the environmental changes in the water bodies, zooplankton is playing key role for the monitoring due to quick response to natural disturbances. The natural and anthropogenic disturbances like hydrology, nutrient enrichment, land-use, salinity, temperature and predation pressure may strongly influence the species composition of zooplankton.

Kocaçay River Basin located in the Coast of Marmara Sea is severely influenced by the industrial and agricultural pollution. The aim of this study is to observe population diversity and density of zooplanktonic organisms and to evaluate with main ecological parameters for future monitoring studies. Samples were collected using by standard plankton net by vertical and horizontal hauls in 3 different station of river basin from December 2013 to November 2014 and fixed in Lugol's solution (4%). To determine the zooplankton abundance, ten liters of water were collected using tube sampler and filtered through a 20 µm mesh-size filter and counted under binocular microscope as well. During the sampling physical (water temperature, conductivity, salinity, dissolved oxygen, pH and Secchi) and chemical (anions and cations) were measured.

Totally 35 zooplankton taxa were identified and the rotifers were the dominant taxa in the basin particularly during spring and early summer while copepods were higher in fall. Cladocera particularly small sized taxa were observed generally in winter periods.

Preliminary results confirmed that zooplankton population density were close related with changed biotic and abiotic parameters.

Key Words: Zooplankton, Kocaçay River Basin, Chl-a, Physico-Chemical variables

SENSITIVITY OF LACCASE ACTIVITY TO THE FUNGICIDE TEBUCONAZOLE IN DECOMPOSING LITTER

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The present study investigates the sensitivity of laccase activity to the fungicide tebuconazole (TBZ) in order to seek for new functional toxicity descriptors in aquatic microbial communities associated to decomposing litter. With this aim, we analyzed the sensitivity of laccase from the different microbial components (fungi and bacteria growing separately and in co-existence), as well as that of their corresponding enzyme fractions (cell bound and diffusible), forming microbial communities in Alnus glutinosa leaves. Results show that fungi are pivotal for laccase in leaves and that their activity is repressed when they co-exist with bacteria. The sensitivity of laccase to TBZ was only detectable in leaves colonized by fungi separately (Alatospora acuminata populations), but absent in those colonized by bacteria alone and/or mixed fungi plus bacteria. Specifically, the increase of TBZ concentration enhances laccase in Alatospora acuminata populations but decreases ergosterol concentration as well as the amount of 18S RNA gene copies. This activity response suggests a detoxification mechanism employed by the fungus in order to reduce TBZ toxicity. Besides, enzyme fractioning showed that laccase activity in the cell bound fraction (76% of the total activity) was sensitive to the fungicide, but not that in the diffusible fraction (24% of total activity). Hence, TBZ would influence laccase activity in the presence of fungal cells but not in enzymes already synthesized in the extracellular space. The present study highlights the importance of the biological complexity level (i. e. population, community, ecosystem) when seeking for appropriate functional ecotoxicity descriptors in aquatic microbial communities.

ECOLOGICAL SCENARIOS FOR THE PROSPECTIVE RISK ASSESSMENT OF AQUATIC ECOSYSTEMS

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Identifying most sensitive species in a given ecosystem is a key challenge to risk assessors. Current risk assessments lean on testing common standard test species, like Daphnia magna among invertebrates. However, these species might not be representative for all species present in aquatic ecosystems concerning their sensitivity to stressors. This study therefore explores a methodology that enables pinpointing most sensitive species based on their biological traits and use them for the construction of ecological scenarios. Interspecies variation in sensitivity to toxicants is suggested to increase with increasing toxicological specificity of the toxic mode of action (MOA). Therefore narcotic compounds with a non-specific MOA were tested. The relative sensitivity of invertebrates to these compounds was calculated and related to biological trait information. Resulting multiple regression models were used to predict the sensitivity of the communities of the Water Framework Directive (WFD) ecoregions for rivers and lakes, in order to verify their suitability as a foundation for ecological scenarios. Results show that the sensitivity of invertebrates to narcotics is indeed related to biological traits like mode of respiration, life duration, and body size. The WFD ecoregions showed little variation considering their sensitivity to narcotics. This might be due to the large spatial scale of the regions, allowing functionally diverse communities in all regions, equalizing average traits composition. Further research should focus on improving ecotoxicological, traits and MOA-databases and on exploring different spatial scales for ecological scenario development. With these aspects improved, this methodology can form the foundation for more realistic ecosystem models.

RELATING CHEMICAL POLLUTION TO BIOLOGICAL EFFECTS IN THE FIELD

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The contamination of freshwater systems with thousands of industrial, agricultural and household chemicals is a major public concern, but long-term effects on aquatic flora and fauna are largely unknown. It is hypothesized that micropollutants play an important role for the ecological deterioration of streams and failure to achieve good ecological status as demanded by the EU water framework directive.

To explore the relationship between chemical pollution and ecological effects in the field, we compiled a large data set from macroinvertebrate and chemical monitoring programs in Germany. Different macroinvertebrate based indices (ASPT, saprobic index, % EPT, BMWP score, SPEAR %, MMI) indicated ecological status. Indicator substances (i.e. caffeine and carbamazepine) and toxic units with regard to pesticides (TUpesticides) characterized chemical pollution. Using several single and multivariate statistical approaches as well as Threshold Indicator Taxa ANalysis (TITAN) the relative importance of micropollutants compared to traditional physicochemical water quality parameters was evaluated.

Results suggest that traditional water quality parameters such as oxygen depletion and salinity are still major determinants of the ecological quality of streams. However, a clear impact of wastewater and wastewater associated compounds was also apparent, suggesting the need for continued efforts to reduce chemical loads in streams.

ANTIBIOTICS PREVALENT IN EUROPEAN SURFACE WATERS CAN INDUCE BACTERIAL ADAPTATION

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Antibiotics have been used in large quantities for many decades but it is only in recent years that they have been investigated in order to make an assessment of the environmental risks they may pose. There is extensive evidence showing that antibiotics are ubiquitous in freshwater systems. While the antibiotics are applied to fight pathogenic bacteria, non-target organisms living in these freshwaters will inevitably be exposed. Antibiotics are found at very low concentrations in surface waters, however it is known that even sublethal concentrations can select for antibiotic-resistant bacteria. We tested the effects of four antibiotics (ciprofloxacin, ofloxacin, sulfamethoxazole and sulfapryridine) on the bacterium Pseudomonas fluorescens at four different concentrations (12, 16, 24 and 48 µg/L). All four antibiotics are the most prevalent in European surface waters and we show that two of them can reduce bacterial numbers over short time scales and induce bacterial resistance to antibiotics.

SYNTHETIC CHEMICALS AND GLOBAL CHANGE

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Concerns about the proliferation and harmful effects of synthetic chemicals, including pesticides, drugs and personal care products, were an important impetus for the modern environmental movement more than 50 years ago. Although synthetic chemicals fulfill all criteria as agents of global change, they have been largely ignored in large-scale analyses. Instead, pollution of freshwater and other ecosystems by synthetic chemicals is typically considered at small scale and for single compounds. We compiled data on the rates of change in the production and variety of pesticides, pharmaceuticals, and other synthetic chemicals over the past four decades and compared these rates with trends in atmospheric CO2 concentrations, nutrient pollution, habitat destruction, and biodiversity loss, all well-recognized drivers of global environmental change. Our comparison shows that increases in synthetic chemical production and diversification, particularly within the developing world, outpaced these other drivers of global change. This highlights the grossly underrated scale of potential impacts caused by synthetic chemicals on freshwater ecosystems and beyond.

ENVIRONMENTAL POLLUTANTS AND THEIR METABOLITES IN FRESHWATER FISH: INTEGRATING EFFECTS ACROSS MULTIPLE BIOLOGICAL LEVELS

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Urban pollutants, such as phthalates, pyrethroid insecticides and polycyclic aromatic hydrocarbons (PAHs) are frequently detected in freshwater. A key factor in their toxicity is their biotransformation into reactive metabolites, which may lead to DNA damage and oxidative stress. The first goal of this project was to describe the trophic transfer of these three classes of chemical pollutants and their products of biotransformation in freshwater ecosystems, from biofilm and plants, to macroinvertebrates and fish species. Then, levels of phthalates, pyrethroids and PAHs, as well as their metabolites were investigated in the European chub (Squalius cephalus, N = 130) and in its environment (water, sediment and biofilm) at the scale of the Marne river basin, France. Biological damages at the molecular level were assessed through biomarkers of genotoxicity and oxidative stress, which could be predictive of reproductive impairment and transgenerational defects in fish species. At the organism level, general health status was determined through the Fulton‘s condition factor, the hepatosomatic index and eco-pathological lesions. At last, fish species diversity was monitored, using environmental DNA survey, in order to explore fish community disturbances. First results of this integrative approach show that the studied sites greatly differed in pollution levels and biological damages in the chub. Correlations between individual exposure to these environmental pollutants and effects at multiple biological scales will be discussed.

FUNCTIONAL RESPONSES OF BENTHIC MICROBIAL COMMUNITIES TO CHEMICALS: AN OMICS BASED INTEGRATIVE APPROACH

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Benthic microbial communities constitute a key compartment of aquatic ecosystems since they ensure many services such as biogeochemical cycles or pollutants degradation. That means that they are crucial for ecosystem functioning (defined as the overall performance of the whole ecosystem). In the environment, these communities are exposed to stressors (e.g. chemicals) which are known to potentially induce structural and functional changes. Many studies report causal links between chemicals and functional responses (through direct assessment or proxy) but little is known about the involved biochemical pathways supporting specific functions. The recent raise of meta-OMICs approaches (e.g. transcriptomics and metabolomics) offers the potential to explore pathways involved in functions at the community level. Based on these methods, we aim to identify the responses of microbial community functions across different biological organization levels to improve linkage of pathways, responsive to chemical exposure (e.g. various mode of action), to ecosystem functioning. As part of a literature research, we address the following questions: (i) what are important functions supported by benthic microbial communities, (ii) which pathways supporting these functions are already known (iii) what are the methods currently used to assess these functions at different biological levels (iv) which modes-of-action interfere with these functions?
The information obtained from an integrative approach could help (i) to gain a mechanistic understanding of toxicant-induced effects on microbial community functions, (ii) to extrapolate responses across biological organization levels and (iii) to point out early warning endpoints.

SYNERGISTIC INTERACTION OF ENVIRONMENTAL STRESSORS AND TOXICANTS DETERMINE COMMUNITY COMPOSITION

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Toxicants and other, non-chemical environmental stressors contribute to the global biodiversity crisis. Examples include the loss of amphibians and the general reduction of aquatic biodiversity. However, the obvious impacts occur at low stress levels that are not expected to result in significant population effects. The presentation identifies such low-level stress - effect relationships for aquatic communities in streams affected by oil-sands exploitation, agricultural pesticides and waste water treatment plants. Applying experimental investigations on combined effects of environmental stressors and toxicants the obvious mismatch the field based stress - effect relationships could be reconciled. Based on these results an approach is provided that quantitatively predicts the highly synergistic direct effects of independent stressor combinations.

NATURAL DISSOLVED ORGANIC MATTER DECREASES TOXIC EFFECTS OF HERBICIDE MIXTURES TOWARDS FRESHWATER MICROALGAE

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As primary producers, microalgae are the basis of aquatic food webs. Thus, they can be directly impacted by herbicides which are, in turn, affected by complex and changing conditions of freshwater environments. For instance, dissolved organic matter (DOM) may interact with pesticides and affect their fate and ecotoxicity. Therefore, the present study aimed to investigate whether the natural DOM influences the toxicity of herbicide mixtures towards two freshwater microalgae.

To that aim, a diatom (Gomphonema gracile) and a chlorophyte (Sphaerellopsis sp.) isolated from a pristine river were exposed to a mixture of three herbicides, with or without natural DOM. Herbicide concentrations were selected to represent environmentally realistic conditions (0.05µg/L for irgarol and diuron, 0.5µg/L for metolachlor) and a 10-times higher exposure. The responses of the microalgae were assessed over a growth cycle, by monitoring daily their growth and photosynthetic efficiency. On the last day, the intracellular relative lipid content was quantified, as well as the proportion of bacteria in the microcosms to ensure no bloom had occurred.

In the absence of DOM, photosynthetic activity decreased in Sphaerellopsis at both concentrations of herbicides, whereas Gomphonema was only impacted at the highest one. DOM alone had no influence on the parameters measured for Gomphonema, but significantly stimulated the growth of Sphaerellopsis. Surprisingly, combined exposure to DOM and herbicides removed the toxic impacts observed without DOM for both species.

Our results demonstrate species-specific responses to DOM and herbicides, and highlight a mitigation of pesticides impacts towards microalgae in the presence of natural DOM.

DETECTING MACROINVERTEBRATE INDICATOR TAXA TO MINING STRESS GRADIENTS WITHIN THE NALON RIVER BASIN (NORTHERN SPAIN)

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The invertebrate community responses to different metal exposure routes in the Nalon River basin (N Spain) were evaluated following a Reference Condition Approach. Traditional multivariate and graphical community routines (PRIMER-E package) and Threshold Indicator Taxa Analysis (TITAN2 routine, R package) were performed over abundance data from 14 reference and 16 test sites, covering all river types present in the basin. Our main objective was to identify sensitive indicator taxa to mining pressures, with potential for being subjected to bioaccumulation analyses in an ecological risk assessment to metals. Ordination results showed that although the considered typology underlies reference invertebrates sites grouping (intra-type similarities 64-72%), inter-type similarities are high (55-68 %) as a reflection of the study area covering a single basin. A general tendency to increasing dissimilarities between references and test mining sites was also observed for most types, especially regarding test sites within Hg an Au mining areas. TITAN analyses produced on pressure gradients extracted from: 1) the first PCA axis including water chemistry and sediment particle size distribution, TOC and metal concentrations, and 2) a new sediment quality index under development in this study. Both gradient analyses were highly coincident in terms of sensitive taxa detected (most taxa corresponding to EPT families), and were supported by SIMPER results. The study revealed the importance of mining derived pressures within the Nalon basin, and highlights the utility of TITAN and the proposed sediment quality index to detect sensitive taxa for ecological quality assessment purposes.

HERBICIDE SENSITIVITY OF STREAM BIOFILMS GROWN AT CONTRASTING HYDRODYNAMIC CONDITIONS - A MESOCOSM STUDY

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Biofilms in rivers are complex communities built of bacteria, fungi, green algae, diatoms and protozoa embedded in a matrix of extracellular polymeric substances (EPS). They are important biogeochemical hotspots in aquatic systems. Their community composition and physical structure is influenced by the hydrodynamic regime, respectively the turbulent flow field near the streambed. Even though biomass and thickness of biofilms decrease with higher and more turbulent flow, the cell-to-EPS ratio increases. Therefore, differences in assemblage tolerance towards herbicides are expected, as biofilm assemblages grown in turbulent conditions showed a lower tolerance as biofilms grown in laminar conditions. Still, correlations between precise values of near streambed flow field and herbicide tolerance are missing. Using an artificial flow-through channel and water from the River Selke (Elbe catchment), we created heterogeneous flow regimes and try to associate biofilm assemblage structure and function to the different hydrodynamic conditions. Afterwards herbicide tolerances of biofilm samples from selected hydrodynamic conditions are tested in the laboratory. Focusing on the phototrophic part of the biofilm communities, we 1) investigate the algal assemblage structure and function under different hydrodynamic conditions (biomass, algal assemblage composition, photosynthesic activity, pigment patterns) and 2) test if they show different tolerances towards a PS-II inhibiting herbicide by using short-term tests of exposure to prometryn. Results are assessed and discussed under the concept of pollution-induced community tolerance (PICT).

LARGE-SCALE STUDY ASSESSING XENOBIOTICS CONTAMINATION EFFECTS ON AQUATIC MICROBIAL COMMUNITIES ASSOCIATED TO LEAF DECOMPOSITION

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In the actual scenario of global change resulting from human activities, streams act as main receiving ecosystems of a large variety of xenobiotic compounds. Therefore, chemical contamination exercises a high pressure on streams, threatening heterotrophic microbial communities and their organic matter decomposition abilities.
In this study, relationships between water chemical contamination and the structure and function of leaf-associated microbial communities, were assessed in six French streams (on upstream and downstream) presenting different contamination gradients over four seasons (spring, summer, autumn and winter). Xenobiotic toxicity (calculated as toxic units (TU) for polycyclic aromatic hydrocarbons (HAP), pesticides and pharmaceuticals, separately) and environmental parameters (including nutrients, temperature) for each site were related to litter decomposition rates (Kdegree-day), structure (biomass, diversity) and enzymatic activities of microbial communities associated.
Preliminary results on spring and summer showed a high toxicity in the most contaminated sites ($\Sigma TU > 0.1$, mostly pesticides and pharmaceuticals), compared to the less contaminated ($\Sigma TU < 0.00008$). Redundancy analyses (51.5% of the variance explained) showed that litter decomposition rates, fungal biomass, and ligninolytic activities were negatively correlated with pesticide toxicity (ΣTU) and nutrient concentrations (dissolved organic carbon and phosphate), while no effect were observed on bacterial community. Moreover, toxic effects of pharmaceuticals and HAP on microbial communities appeared minor compared to pesticides (< 5% of ΣTU on average).
Overall, our study indicates that xenobiotics contamination tends to negatively impact structure and function of fungi associated to submerged leaves, and highlights the importance of these communities for ecotoxicological risk assessment in stream ecosystems.

RELATIONSHIP BETWEEN BIOMARKERS RESPONSES OF A GLACIAL RELICT AMPHIPOD EXPOSED TO CHEMICAL STRESS

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Aquatic environments are increasingly loaded with environmental contaminants.These pollutants may trigger a variety of toxic responses in the exposed animals. One of the most significant challenges is the early prediction ofdifferent impacts using specimens of aquatic animals collected in the field; this is frequently advocated as the main objective for development and validation of sub-organismal biomarkers.However, the biomarker responses are often interlinked, which complicates interpretation and assessment, particularly at low exposure levels. In this context, we aimedto study the effect of low-to-moderate chemical stress on the relationship between commonly measured biomarkers in order to better understandthe complex responseto the exposure. We conducted a mesocosm experiment with amphipod Monoporeiaaffinis (Lindström, 1855)exposed to amixture of PCBs and PAHs of low specific toxicity at ecologically relevant concentrations. After 22 days of exposure, we measured biomarkers acetylcholinesterase (AChE), oxygen radical absorbing capacity (ORAC), lipid peroxidation and protein content to determine the physiological status of each individual. Additionally, we measured mortality and RNA:DNA ratio as a proxy of growth rate. The relationships among the biomarkers were evaluated by regression analysis and will be discussed in the context of developing a cost-effective ecotoxicological assessment tool.

SWIMMING OR JUMPING? PASSAGE BEHAVIOUR OF A POTAMODROMOUS CYPRINID UPON NEGOTIATING AN EXPERIMENTAL WEIR SUBJECTED TO DIFFERENT DESIGN CONFIGURATIONS

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River fragmentation by small weirs is considered one of the main causes that negatively affect potamodromous cyprinid fishes, because they block upstream movements which species seasonally need to undergo for reproduction purposes. Though recent studies have addressed the effect of hydraulic parameters on upstream movements past small weirs, little is known on how these parameters interact to induce a swimming or a jumping behaviour in negotiating such obstacles. This study aims to evaluate the passage behaviour (swimming vs. jumping) of Iberian barbel (Luciobarbus bocagei), over an experimental small broad-crested weir, considering the effect of key hydraulic parameters: plunge pool depth (D), waterfall height (Δh), and flow discharge (Q). A total of 16 configurations were tested contemplating different combinations of D (10, 20, 30, 50 cm) and Δh (5, 10, 15, 25 cm) with a constant Q (50 L.s-1).The configuration with the highest passage success was tested for different discharges (Q=25, 75, 100 L.s-1). Results showed that passage behaviour was highly dependent on the configurations (DxΔh) tested (Freeman–Halton test, $p<0.0001$) and that both factors (D and Δh), and their interaction (DxΔh), were significantly correlated with it (PerMANOVA, $p<0.01$). Except for Δh=25 cm, barbel negotiated most configurations by swimming. Thus, higher Δh proved to be preponderant in switching passage behaviour from swimming to jumping. Concerning Q, there was no evidence that passage behaviour was discharge related (Freeman–Halton test, $p>0.05$). These outcomes are useful to identify potential migration obstacles, or designing fishways, for this and other medium-sized potamodromous cyprinids.

THE VALUE OF A DESK STUDY IN BUILDING A RIVER OBSTACLE INVENTORY

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This paper evaluates a desk-based approach for creating an inventory of man-made obstacles or barriers in rivers, such as dams, bridge aprons, weirs, and culverts. It is part of an Environmental Protection Agency funded project (Reconnect) to study the impact of obstacles on hydromorphology, aquatic ecology and connectivity in Irish rivers.
The creation of a river obstacle inventory is a logical first step in developing a prioritisation process for obstacle removal and/or modification. An efficient desk-based method of locating obstacles using various maps is presented. As an example, a desktop GIS analysis was undertaken of two rivers and their tributary network, using historic maps, satellite imagery and OSI discovery series maps, to create a geo-referenced layer of all the potential obstacles. In order to determine the effectiveness of the desk study, the located obstacles were cross-referenced with obstacles recorded in the field.
The desk study identified several thousand potential obstacles, of which over 80% were road crossings. Over 90% of the obstacles located in the field were successfully identified via the desk study.
The results of this research indicate that a desk study can be an efficient and effective method of locating river obstacles and can guide subsequent field surveying of the obstacles, in particular eliminating large stretches of the river that would otherwise need to be walked, thus reducing the time and cost involved.

SUCCESSION DYNAMICS OF BIOFILM AND MACROINVERTEBRATES FOLLOWING FLOODING AND ARTIFICIAL CLEAR WATER RELEASES IN A MEDITERRANEAN-CLIMATE RIVER (DURANCE, FRANCE)

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The Durance River (southern France) is a highly regulated, gravel-bed river with a naturally high fine sediment load. Flow regulation (8 dams, 16 hydropower plants along 218 km below Serre-Ponçon Dam) has contributed to clogging. Annual clear water releases are used to reduce superficial clogging and are associated with long-term monitoring. The succession dynamics of benthic invertebrates and biofilm in a reach subject to both occasional natural floods and clear-water releases were characterized (natural MAF = 122 m3/s). Riffles were sampled regularly during 4-months following a natural flood (1200 m3/s) and before/after a clear-water release (70 m3/s) and compared to benthic clogging conditions. Clogging remained low (< 25%) 4-months post-flood, but was not changed (50%) following the release, which was therefore of limited efficacy. Biofilm communities included cold-water, rheophilic diatoms (e.g. Hydrorus foetidus) immediately post-flood, followed by the arrival of cyanobacteria. Filamentous algae (Cladophora) dominated in all campaigns post-release. Invertebrate communities were slow to recover post-flood, demonstrating a distinct recolonisation process by species associated with unclogged conditions (e.g. Oligonuriella rhenana). The clear water release did not disturb succession dynamics in 2016 compared to a reference station. The influence of biofilm development on invertebrate composition was also investigated.

RIVER RESTORATION SCHEME TO IMPROVE MIGRATORY PATHWAYS FOR POTAMODROMOUS CYPRINIDS

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Sabor River a tributary of the Douro River (N. Portugal) was one of the last wild Iberian rivers. Sabor hydropower dam was recently constructed, blocking fish migration immediately at the river mouth. As a compensation measure the downstream segment of Vilariça R., an impacted tributary running parallel to main stream, was elected for restoration to replace some of the lost areas. The aim was to create spawning grounds and to improve the migratory pathways for the potamodromous cyprinids from Douro River, especially Luciobarbus bocagei. Water from the Sabor reservoir was derived in a submerged channel to the lower Vilariça R. to increase the water flow, but it was necessary to define the most appropriate volume of water to be released. Restoration included also: submerged weirs with fish ramps to increase the lotic/ lentic sequence, lunkers, bank reinforcement, and river water profile increase. Field work took place during the spawning season. To build the 1D model, 45 river-bed profiles were taken, as well as hydraulic measurements (i.e. velocity and depth) at 6 cross-sections. The CASiMiR Fish model together with the 1D Hec-RAS was used to calculate the Weighted Usable Area (WUA) in the spawning season considering the river morphology after the restoration scheme. Fuzzy sets and rules for two life-stages of the Iberian Barbel were defined based on expert knowledge and fish surveys. This study allowed to define the minimum flow to promote and maintain the spawning grounds and also the efficiency of the integrate rehabilitation.

ASSESSING THE HABITAT SUITABILITY FOR REINTRODUCTION OF BROWN TROUT (SALMO TRUTTA): A MODELLING APPROACH

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Due to deterioration in previous decades the ecological river water quality reached an absolute minimum during the 1990ies in many European rivers. Large and small rivers suffered from hydromorphological degradation and were characterized by a poor chemical water quality. This facilitated the loss of key species and promoted a general loss of biodiversity in Europe's freshwater ecosystems. Since the enforcement of the European Water Framework Directive in 2000, the ecological water quality has drastically increased, allowing the recolonization and restoration of freshwater biota. Clear and robust guidelines are needed to obtain cost-efficient solutions in river management. Habitat suitability models have proven to be useful to support decision making in river management. In this study, we developed species distribution models, based on habitat preference curves, to define the biological response of a species (presence/absence) to abiotic gradients. This allowed us to indicate the conditions and locations which are suitable for the (re-)introduction of brown trout, a rheophilic fish species, in the Zwalm river basin (Belgium). Based on an ensemble approach, we found that temperature, stream velocity and pool/riffle pattern are the most important variables determining the occurrence of the species. By linking the outcome of our models to the actual water quality conditions of the river basin, we are able to pinpoint the most suitable locations for the reintroduction of brown trout. Our results show that using such a modelling approach is valuable to support reintroduction programs in the Zwalm river basin or other river basins in Europe.

COLONISATION OF THE RESTORED STREAM BY BENTHIC INVERTEBRATES: A CASE STUDY FROM THE BOHEMIAN FOREST (CZECH REPUBLIC)

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In the Czech Republic, the vast majority of stream restoration projects have been focused on technical improvement of the channel morphology of small streams and their in-stream habitat enhancement. They have included mostly re-meandering of streams, construction of small impoundments, and sediment removal from backwaters and impoundments on streams to improve stream hydrology and water retention in the floodplain. Biological responses to restoration, however, are rarely monitored or evaluated methodically and the post-project evaluation of implementation of the primary restoration goals is lacking.
Our monitoring survey is focused on the restoration of the lower stretch of the mountain stream Hučina in the Bohemian Forest (Šumava NP) which was returned to its original meandering course by complete restoration of its channel. Simultaneously, its modified channel and drainage channels in the floodplain were blocked or buried. The long-term monitoring focused on both benthic invertebrates and in-stream habitat development began immediately after the restoration in November 2014. Our results of two-year monitoring after the restoration show surprisingly rapid colonisation of invertebrates, though the conditions are not yet favourable for some species. Remarkably species-rich and numerous communities of invertebrates were found shortly after the restoration and fish and lampreys were observed repeatedly. Due to unstable (fine) bottom substrate, however, benthic invertebrates are vulnerable to high water discharge after spates and further development of their communities will be related on the bottom substrate conditions.

EFFECTS OF HYDROPEAKING AND SHELTER CONFIGURATIONS ON THE BEHAVIOUR OF CYPRINIDS IN AN EXPERIMENTAL FLUME

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The effects of hydropeaking on fish movement behavior and physiology have been scarcely addressed. Few studies propose mitigation measures and assess fish responses afterwards. We investigated the effects of pulsed flows (changing in magnitude, duration and frequency) on the movement behavior and blood physiology (glucose and lactate levels) of Iberian barbel. The study was conducted in an indoor flume (8.1m*0.7m*0.8m) equipped with PVC flashboards and plywood structures simulating natural deflectors and instream habitats. The velocity field was characterized using ADV and FLOW 3D modelling to correlate the movement behaviour with the created hydraulic conditions. Movement patterns and physiological changes evidenced that Iberian barbel was affected by the degree of unpredictable flow changes. Fish sprints, more energetically demanding, and fish drifts associated to the fish drag caused by flow, increased with higher magnitudes and durations. Deflector downstream approaches were more frequent at higher magnitudes and durations indicating that fish sought velocity shelters to avoid harsh hydraulic conditions. Blood glucose levels increased in the single up-ramping event for the highest magnitude. Pulsed flows seem to promote physiological changes in Iberian barbel, however this trend was not evident for all hydropeaking events and shelter configurations. Although the results for the instream plywood shelters are still under analysis, preliminary observations suggest that lateral shelters (deflectors) are preferred over instream shelters (plywood structures). This research presents a novel approach by combining hydropeaking events with fish movement behavior and blood physiology and expects to contribute to the design of more fish friendly habitat mitigation measures.

A TECHNIQUE TO ASSESS RIVER HABITAT CHANGE – THE MISSING DIMENSION FOR WATER RESOURCE MANAGEMENT

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Conservation of healthy and stable native fish populations depend on ensuring there is an adequate quantity and quality of habitat for all species present in a river or stream. River engineering and management activities have the potential to have significant adverse effects on habitat quantity and quality. The event Habitat Quality Index (eHQI) provides a simple way to record the change in habitat characteristics relevant for specific native fish at any river reach. We identify the key geomorphological variables that have been determined to assess habitat for each of 10 native species of fish. All variables in Table 1 for each species of fish predicted to be present at a site according to the River Environment Classification should be measured before and after any management activity. Each of these variables should be expressed as a ration of measure after / measure before such that a ratio of 1 would represent no change. The median of all component eHQI's yields the eHQI. A decline of more than 15% in this index, or a decline of more than 40% in any single component would indicate cause for concern and the need for potential mitigation activity.

EXPERIMENTAL FLOODS – QUANTIFYING STRUCTURAL HABITAT CHANGES IN A SWISS FLOODPLAIN USING UAV REMOTE SENSING

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Experimental floods increasingly serve as a management tool for river restoration. In this context, quantifying structural impacts of experimental floods are crucial information to rate and adapt hydrological management schemes for ecological and economic purposes. Currently, this information is largely achieved through modelling approaches with several uncertainties through ground surveys, which are time-consuming and spatially limited, or through expensive and equipment intense photogrammetric assessment.

To address these issues, we deployed a light-wing UAV equipped with capable sensors (RGB and near infrared) and developed a photogrammetric and remote sensing approach as an efficient and flexible monitoring tool for quantifying structural habitat changes in a 3-km long residual flow section (discharge = 3.5 m3/s) of the heterogeneous Sarine floodplain (Canton Fribourg; Switzerland) subject to an experimental flood (255 m3/s) in September 2016. Analyses of UAV surveys before, during and after this flood have shown that this event induced habitat turnover and renewed dynamics of the system. In particular, morphological changes in the size and location of gravel bars and erosion of non-flood resistant vegetation patches were evident.

Overall, this approach provided timely and critical information at the floodplain scale on how this floodplain structurally responded to induced disturbance by an experimental flood. This has fundamental significance for the future design and dimension of experimental floods including the ecological and economic perspective for adaptive management programs of floodplains.

NON-UNIFORM-FLOW REGIME CONDITION EFFECTS ON FISH PASSAGE SUCCESS IN AN EXPERIMENTAL POOL-TYPE FISHWAY

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On a global perspective, anthropogenic structures within rivers highly fragment the fluvial continuum causing fish population declines. Vertical slot fishways have the ability to allow fish to negotiate cross walls at their desired depth, enhancing connectivity in fragmented systems. Even well designed fishways may suffer from errors during construction, differences in discharge, headwater and tailwater level to the design requirements which can result in non-uniform scenarios - rarely does a fishway functions as intended. This study aims to assess the effects of two different non-uniform scenarios by comparing them to a uniform scenario in an experimental full-scale pool-type fishway. Schools of five wild fish (Luciobarbus bocagei – a mid-size potamodromous) were used to determine fish negotiation performance in each regime – Drawdown (hm 0,74 m; Q 50 L/s), Uniform (hm 0,8 m/Q 81 L/s) and Backwater (hm 0,62 m/Q 81 L/s). Water velocity components were measured with an Acoustic Doppler Velocimeter at different water planes parallel to the fishway bottom, allowing to characterise the hydraulic environment within the fishway in all tested regimes. Furthermore, water pressure measured with an artificial Lateral Line Probe allowed determining how the flow around a fish body acts along video-tracked fish positions. Significant differences in passage success and behaviour were observed between the regimes, highlighting the impact of non-uniform conditions in the field. This study shows how fish experiments under non-uniform scenarios are paramount to better define design criteria to allow fishways to be functional in multiple situations.

"LOCK AND GROW" - A RESTORATION STRATEGY TO INHIBIT THE FORMATION OF BENTHIC ALGAL MATS

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The Reither See (area 1.5 ha; max. depth 7.7 m) is a popular recreational lake located in the state of Tyrol, Austria. The natural lake became increasingly eutrophic during the sixties due to inflows containing minimally processed wastewater and run-off from the surrounding agricultural catchment. Different measures (improved water quality of inflows; hypolimnic withdrawal; application of iron(III)chloride) improved lake water quality in the early seventies.

Although nutrient loads have been reduced since then, in recent years a new problem needed to be tackled. The emergence of massive mats of floating benthic algae covering much of the lake's surface, especially during the summer months, has reduced the appeal of the lake to swimmers and tourists.

A comprehensive investigation of the interactions between sediment, water quality, phytoplankton and the hypolimnetic withdrawal was undertaken in order to understand the processes driving the development of these algal mats.

A combination of measures resulted in a significant reduction of floating mats. Lanthanum modified bentonite (LMB) was applied to bind phosphorus at the sediment surface, where the algal mats had their origin. In a second step, stoneworts (Charophyta) were planted as natural competitors in the littoral zone of the lake bottom. The poster presents the successful strategy to inhibit the formation of the floating algal mats.

REMOVAL OF NAPROXEN FROM WATER IN THE PRESENCE OF CERATOPHYLLUM DEMERSUM

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Non-steroidal anti-inflammatory drugs have become a considerable source of environmental contamination. The aim of this study was to determine the effect of the presence of hornwort on the removal of naproxen from water.
SIS growth medium was used as a base to prepare the naproxen solution (10 mg.dm-3) and as solution for the control probes. The first three containers were filled with 250 cm3 of naproxen solution each and another three were filled with 250 cm3 of the SIS growth medium each (control group). 6.00 g of the fresh mass of Ceratophyllum demersum were placed in every container. The experiment was conducted in a climatic chamber. The measurements of the mass of Ceratophyllum demersum and the concentration of naproxen were conducted on the first day of the experiment and after 10 days of the exposition. The concentration of naproxen was determined with the use of an Agilent Technologies 1260 Infinity liquid chromatograph. The results of the experiment were statistically processed using one-way analysis of variance. The analysis of the biomass showed that the development of Ceratophyllum demersum was not affected by the naproxen contamination. The plant took part in 18% of the substance removal, of which the bioaccumulation was responsible for 15%.

TOP-DOWN EFFECTS OF FISH IN EUTROPHIC RIVERS

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In the River Nister, an eutrophic river in the low-mountain range Westerwald (Rhineland-Palatinate, Germany), the biomass of benthic algae has strongly increased over the last decade although nutrient concentrations remained fairly constant since the early 1990s. The increase of algal biomass coincided with a substantial decrease in the population of large sized fish such as the herbivorous nase (Chondrostoma nasus). Expecting a causal connection between the two observations, we investigated whether herbivorous fish are able to reduce benthic algae in eutrophic rivers by performing exclosure experiments to quantify effects of C. nasus on algal biomass. Electric fences prevented fish from foraging on standardized concrete tiles exposed on the stream bottom. Three experiments were conducted at low, moderate and high fish density, respectively. We hypothesized that at moderate and high fish density, algal biomass would be lower in the controls than in the exclosures due the foraging activity of C. nasus. Contrary to our expectation, algal biomass was significantly higher in the controls even at high fish density, indicating a low impact of fish grazing. We suspect that exclusion of small benthivorous fish might have enhanced the biomass of invertebrate grazers in the exclosures, leading to more intense grazing than in the controls. Consequently, cascading top-down effects of benthivorous fish seemed to have a higher impact on the algal biomass than direct effects of herbivorous fish.

BIOMANIPULATION IN MULTIFUNCTIONAL URBAN IMPOUNDMENTS – ATTEMPT TO RECONCILE WATER QUALITY AND SERVICES FOR SOCIETY

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Impact of stocking with piscivorous fish was tested in two small urban impoundments in Arturówek (upstream pond – UP and downstream pond - DP, respectively) at the northern border of Lodz in Central Poland (LIFE08 ENV/PL/000517), as one of the recultivation measure considered to be applied in Borki reservoir in Radom (LIFE14 CCA/PL/000101). Pike Esox lucius and pikeperch Stizostedion lucioperca, were stocked separately, in UP and DP respectively, since autumn 2013. Stocking was preceded by the sediment removal and the construction of biofiltration areas. Fish assemblages were assessed by multimesh gillnetting and a set of environmental variables was also taken into account (concentration of oxygen, nitrate, nitrite, phosphate, bluegreen algae, total phytoplankton, zooplankton groups: Copepoda, Cladocera and rotifers). Before the stocking operation (2010-2011) fish assemblage was dominated by small perch Perca fluviatilis (35.4 %) and sunbleak Leucaspius delineatus (41.7 %) in UP and by small perch (60.8 %) and crucian carp Carassius carassius (20.3 %) in DP. After the settlement of the stock of piscivores (2014-2015) sunbleak remained the most abundant species in both ponds (44.4 and 75.6 % in the UP and DP respectively). However, in UP it was assisted by relatively high share of pike (22.2 %), crucian carp (18.5 %) and ide Leuciscus idus (14.8 %). Besides sunbleak only pikeperch was caught in higher numbers in DP (14.6 %). The influence of piscivorous fish presence (low / high piscivorous fish number) and pond location (UP, DP) on the differentiation of surveyed environmental variables was tested (MANOVA, test NIR) after the reduction of the number of variables with principal component analysis (four PCA variables were explaining 73 % of the variability). The values of the environmental variables differed statistically in the presence of the piscivorous fish (for all PCA variables), while location had minor importance ($p<0.05$ only in case of PCA3). Even though average concentrations of nitrates, bluegreen algae and total phytoplankton decreased, higher quality of the fishery should be considered as the major benefit of the biomanipulation in Arturówek, while not all values of environmental variables (eg. zooplankton biomass) improved after the stocking operation.

FAST RESPONSE OF MICROFAUNAL ASSEMBLAGES TO RESTORATION MEASURES IN THE WESTERN BALKAN PEAT BOG

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Peat bogs are unique wetland ecosystems providing a wealth of heterogeneous habitats for aquatic and terrestrial biota. Due to exploitation, degradation and progressive succession, they are highly endangered ecosystems worldwide, thus making peat bog restoration a priority issue. The aim of this study was to test the early response of microfauna on restoration measures – cutting and mowing, in the Đon močvar peat bog, Croatia. Sphagnum cores were sampled within three main habitat types: restored, successional and control, monthly from April to November 2015. Protozoa and micro-metazoa were determined on live material. Control sites had significantly highest water content, followed by restored and successional sites, and that pattern reflected strongly on microfauna. Out of 70 taxa of protozoa (excluding testacean fauna) and micro-metazoa, the highest diversity was found at control sites (62 taxa, 125 ind./mL on average), followed by restored sites (50 taxa, 125 ind./mL on average) and successional sites (46 taxa, 81 ind./mL on average). Ciliates dominated in microfaunal assemblages at control sites with high abundance of mixotrophic species, characteristic for peat bog microfauna. Rotifers had the greatest share in abundance at restored sites. Convergence between microfauna at control and restored sites increased over time, while microfauna on successional sites became more diverged from those on control sites. Our results indicated fast recovery of peat bog microfauna after revitalisation measures. Therefore, we suggest that microfauna can be used as an early ecological indicator in peat bog restorations, with advantages of easy non-destructive sampling, quick response and high sensitivity.

EXAMINING NITROGEN BIOGEOCHEMISTRY ACROSS THE SEDIMENT-WATER INTERFACE IN RESTORED AND UNRESTORED URBAN LONDON RIVERS – ANNA LAVELLE, NIC BURY, MICHAEL CHADWICK

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Elevated nitrogen (N) concentrations in urban rivers arising from inadequate urban drainage systems and sewage overflows can contribute to in-stream eutrophication and degradation. River restoration projects focussed on restoring flow heterogeneity and encouraging the aggregation of sediments and larger particles can facilitate the transformation, assimilation, and removal of N from urban rivers. We used simple bioreactor assays to examine N processing between the sediment-water interface across five London tributaries to determine the extent to which restoration could influence biogeochemical activity. Mean NH4+ site concentrations during the sampling period ranged from ~36 µg/L to ~731 µg/L delivering significantly higher values at restored sites than unrestored sites (p=<0.001). Corresponding mean NO3- concentrations ranged from ~9 mg/L to ~27 mg/L but did not differ significantly between restored and unrestored sites (p=>0.05). Mean NH4+ consumed and produced ranged from ~ -9 µg/m2/sec to ~ 8 µg/m2/sec whilst corresponding NO3- fluxes ranged from ~ -0.16 mg/m2/sec to ~0.39 mg/m2/sec. We found that physical disturbances resulted in NO3- uptake at restored sites (p=<0.05) but this was not evident across longer time periods. We attribute the variability seen in our results to sediment composition and associated N storage capacities, the effectiveness of restoration management strategies, and legacy effects associated with urban landscaping.

RS08 – Presentation

EXAMINING NITROGEN BIOGEOCHEMISTRY ACROSS THE SEDIMENT-WATER INTERFACE IN RESTORED AND UNRESTORED URBAN LONDON RIVERS – ANNA LAVELLE, NIC BURY, MICHAEL CHADWICK

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MECHANISMS OF SALICACEAE ESTABLISHMENT IN GRAVEL-BED RIVERS: IMPLICATIONS FOR CONSERVATION AND RIVER MANAGEMENT

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Models for establishment of salicaceous riparian trees (poplars and willows) in alluvial rivers predict the elevational range colonised by seedlings assuming that: these trees are obligate phreatophytes, the alluvial water table is planar, linked to river stage, and the capillary fringe is spatially uniform and thus parallel to the groundwater. As they apply at the reach scale, such models are not able to explain local variation, nor why some bars get colonised whilst others not, even if located in similar landscape positions. Finally, current models do not differentiate establishment in sand-bed and gravelly rivers.

We propose new mechanisms that explain establishment of Salicaceae in gravel-bed rivers, over multiple scales. At the point scale, water availability during the first season is the main variable determining success. Both presence-absence and biomass are explained by two physical effects: (i) the water retention capacity of the fine matrix within the bar, which depends on particle sizes, and (ii) the presence of a coarse surface layer (CSL) of clean gravel. A finer soil has more capillarity, resulting in a higher initial moisture, whilst the CSL acts as rock mulch (i.e., as a capillary barrier), strongly decreasing evaporation at the surface. At our field sites, establishment success was uncorrelated to alluvial groundwater levels, which were much deeper than maximum root length, indicating that seedlings are facultative, not obligate phreatophytes.

At the reach scale, we propose the River Seeding Concept for explaining the spatial patterns in establishment of seedlings of salicaceous riparian species: Hydrochory needs to be invoked - instead of groundwater dynamics - in order to explain the arcuate bands of trees documented over a range of fluvial patterns. Wind-dispersed seeds are released en masse by adult trees, deposited on the water, and then entrained in the drift, initiating germination as they are transported downstream. Turbulent diffusion forces some of the advected propagules into the zone with high relative-roughness flow, along gravelly shores, where they deposit and start growing underwater. The river does the seeding, so that the spatial patterns of establishment at the reach scale are fully controlled by hydrology and hydraulics: they depend on the flow profiles at the beginning and end of the period with seed availability.

Our concepts have important consequences for the conservation of riparian Salicaceae in impounded gravel rivers. Instead of unnaturally restricting drawdown rates, as suggested by models based on groundwater dynamics, we propose that flows should be managed to emulate the natural establishment mechanisms. Matching flood recession to the peak in seed availability, which coincides with large drawdown rates in rivers with snowmelt-driven hydrology, should result in a much larger seeded area. In reaches immediately downstream of dams though, the availability of fine sediment could be limiting.

MACROPHYTES INTRODUCED IN NEWLY-DUG PONDS BENEFIT TO BENTHIC MACRO-INVERTEBRATE COMMUNITIES

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The Interreg program C12 „Cistudes Sans Frontières“ („European pond turtles Without Borders“) aims at reintroducing the European pond turtle (Emys orbicularis) in the Upper Rhine region, where it supposedly became extinct at the end of the 19th century. In the framework of this program, freshwater environments have been created and restored in the area chosen for the reintroduction: the hereafter-named „Site du Woerr“, Lauterbourg, France. This site consists in a former gravel pit surrounded by forests and meadows (150 ha in total), where restoration initiatives (softening of the bank slope of the gravel pit and digging of 8 new ponds) occurred since 2011. Here, our aim was: (i) to monitor benthic macro-invertebrate communities (MIC) colonization in relation to restoration initiatives; and (ii) to evaluate the possible impact of turtles on MIC.

First, we show that from 2012 to 2015 MIC's richness and stability increased in the gravel pit and in all ponds. The occurrence of helophytes was a major factor for macro-invertebrates colonization. Ponds that benefited from vegetation planting showed faster colonization and higher MIC's richness, whereas forest ponds exhibited limited macrophytes cover and less diverse MIC. In a couple of ponds, the recent occurrence of the exotic invasive American crayfish Orconectes limosus seemed to limit MIC's richness. Second, we show that pond turtles mostly feed on large insects, without any observable impact on MIC‘s abundance and richness.

Our results indicate that restoration protocols used on „Site du Woerr“ are suitable for local biodiversity and released pond turtles.

HYDROPOWER REGULATION IMPACTS ON POOL-RIFFLE HABITAT IN A BRAIDED GRAVEL-BED ALPINE RIVER

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The aim of habitat simulation in rivers is to build a relationship between streamflow and physical habitat with ecological and biological attributes that characterise species-dependent habitat quality and quantity. As a first step, physical habitat assessment provides a means to quantify the first order control of streamflow on habitat for variable river hydrology and morphology. This task is particularly important when the goal is to analyze the impacts of streamflow changes in regulated rivers, in which case habitat loss is usually counteracted by economic benefits (e.g. hydropower production). However, the competing goals of habitat maintenance and economic gain are not easily quantifiable and it is difficult to assess the uncertainty in their assessment. In this work, we provide the results of a study in which a systematic analysis of physical habitat loss and economic gain by electricity production in a braided gravel-bed Alpine river (Maggia River, Switzerland) was carried out. The construction and operation of a hydropower system in the basin has led to a 75% drop in mean flow in the effected river reach. We use (1) a simplified hydropower system model that computes the flows in the Maggia River as a function of reservoir and intake regulation rules and capacities; (2) a 2D hydrodynamic model (BASEMENT) for the simulation of high-resolution flow depth, velocity, and morphological indices in the downstream braided river; and (3) the simulated probability distributions of physical habitat in the affected reach dependent on streamflow variability in pre- and post-dam periods. For physical habitat, we use the weighted usable area of pools and riffles, which are known to be well correlated with habitat suitability for fish, e.g. trout, in the study siter. The results show that physical habitat loss after dam construction in the Maggia River is substantial and affects mostly riffle habitat. Assuming increasing levels of minimum discharge (environmental flows) as possible scenarios, we use our methodology to quantify the resulting rate of increase in total pool-riffle physical habitat versus the rate of loss in electricity production. This allows us to generate marginal benefit functions for hydropower and river pool-riffle habitat, thus contrasting economic and ecological benefits. Our results also show that un-

certainties in streamflow, for example given by the natural variability in runoff or the operation of the hydropower system reacting to the price of electricity, are key ingredients and limit the confidence in the predictability of impacts. Although the presented methodology uses only pool-riffle area to describe physical habitat, it may be easily extended to any hydraulic-morphological attribute and habitat suitability measure. We envision the use of the methodology for the identification of optimal flow release strategies, which take into account ecological as well as economic benefits in Alpine rivers.

RS08 – Poster

A FIELD QUANTIFICATION OF ALL INCLUSIVE FISH-PASS EFFICIENCY USING A COMBINED TELEMETRY SYSTEM

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In order to overcome fragmentation of mobility corridors, upstream fish-ways are installed worldwide to overcome the inaccessibility of functional habitats and to increase the ecological continuity of rivers. Fish-pass evaluations are increasing but are still often limited to a single species and not adapted to get a complete overview of the overall efficiency. In the lower Bocq River (Belgium) a multispecific vertical slot basin fish pass (300 l.s-1; 7 pools with 0.24m dH) was installed in 2011. A combined RFID and radio-telemetry system was designed and installed downstream the dam and in the fish-pass to analyse fine scale fish individual behaviour. Three fish species (brown trout, European grayling and common barbel) were captured in the river, n=88 fish were tagged and released after translocation 300 m downstream of the fishpass. Different fish passage metrics were proposed and used in order to get a complete view on the global performance of the fish-pass, including attraction efficiency, searching and passage delays and global passage efficiency. The results indicate a major problem in terms of attraction efficiency (40% for the salmonids and 0% for the barbel) with a too long searching delay. For fish that find their way into the fishpass, the passage efficiency was 55% for the grayling and 87% for the brown trout with a reasonable time to cross the structure (median <2 h for both species). Our results underline the necessity of a more holistic approach to evaluate fish pass efficiency using precise metrics and individual tagging.

NUTRIENT REMOVAL EFFICIENCY IN MESOCOSM CONSTRUCTED FLOATING WETLANDS (CFWS)

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Constructed Floating Wetlands, (CFWs) also called planted floating system bed, artificial or vegetated floating islands or ecological floating bed, consists of aquatic or terrestrial plants growing uppon a buoyant frame at a hydroponic manner on the surface of water bodies (Li et al., 2010).

In general, CFWs main functions are: habitat for fish and birds, water purification, literal zone protection and landscape improvement (Dodkins and Mendzil, 2014; Zhu et al., 2011).

In Med-rivers summer droughts decrease water volume, increase hydraulic retention time and decrease river depth (Skoulikidis et al., 2011). Thus, temporary streams and rivers with low flow or connected or disconnected pools may serve as appropriate systems for CFWs application.

This study has been carried out in order to investigate the potential of CFWs for restoring Mediterranean rivers. A mesocosm experiment has been conducted from 1st June till 25th August.

Four parallel open tanks were installed in open air environment. Each of them had 1380 L capacity, with 1.51 m2 (1.64 m L x 0.92 m W) area. Maximum depth was 0.92 m and working/operational depth was maintained at 0.75 m. Hydraulic Retention Time was maintained 7 days.

Four floating mats of 0.90 m2 (1 m L x 0.9 m W) surface area were constructed using Polyvinyl chloride (PVC) pipes (Φ 50 mm), plastic mesh and canvas fiber, while as growth media expanded clay and pumice were used in proportion 2:1. The canvas was used in order to secure that rhizomes would not have contact with the substratum.

Juncus effuses and Scirpus mauritimus were used in order to investigate their efficiency regarding TN, TP and NH4-N removal.

Unit 1 served as control and loading was low. Unit 2 was vegetated with Scirpus mauritimus and loading was low. Unit 3 was vegetated with Juncus effuses and loading was low. Unit 4 was vegetated with Scirpus mauritimus and loading was high.

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Skoulikidis N., L. Vardakas, I. Karaouzas, A. Economou, E. Dimitriou, S. Zogga

LONG-TERM ECOLOGICAL RESPONSES OF THE RIVER SPÖL TO EXPERIMENTAL FLOW RELEASES

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Experimental high flows are becoming popular management tools in flow-regulated rivers globally. The Spöl flows from Livigno reservoir on the Swiss-Italian border within the central Alps. Regulated flows since 1970 decreased the annual discharge of 8.6 to 1.0 m3s-1 (0.55 m3s-1 winter, 2.5 m3s-1 summer) using hypolimnetic water. Thirty floods were released between 2000 and 2015 following an adaptive management strategy. A 100-m long reach ca. 2.3 km downstream of the dam was used during the 17 years of study for measures of water physico-chemistry, periphyton, transported and benthic organic matter, macroinvertebrates and fish redds (Brown trout). Most physico-chemical parameters displayed strong seasonal cycles unrelated to the flow program. Periphyton biomass decreased after each flow event to low levels (<5.0 g m-2), but quickly recovered to higher levels between flows. Seston levels also were low after each high flow and then increased until the next high flow. Benthic organic matter decreased two-fold (usually <5.0 g m-2) once the flood program was started, but also increased between floods. High flows reduced macroinvertebrate densities to <10,000 ind m-2, with densities increasing to ca. 10,000-20,000 ind m-2 between floods. An NMDS analysis revealed clear temporal shifts in the macroinvertebrate assemblage during the study period. Fish red numbers increased from 58 in 1999 to >200 by 2003, but decreased to <30 redds following an accidental sediment spill in 2013. Long-term monitoring was essential for elucidating ecosystem shifts in the river over time and evaluating biological responses to pulse disturbances during the study period.

REINSTATING DISTURBED FRESH WATER ECOSYSTEMS - THE REVEGATION OF WILDLIFE LAKES, PENRITH, NSW AUSTRALIA

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Keywords: Species selection, mine rehabilitation, reinstating disturbed fresh water ecosystems, habitat corridors, riparian vegetation

In Western Sydney, a 2000 hectare fresh water lakes and creek system is being restored. As a perri-urban rehabilitation program, this project presents unique management challenges. The lakes have been totally reshaped from the shale bedrock forming a number of major lakes, surrounding foreshore and terrestrial landscape, hanging swamps, islands and in lake peninsulas. Cumulating in freshwater lakes suitable habitat for iconic wildlife species and the reinstatement endangered freshwater ecological communities.

A range of keystone species (amphibian, aquatic, reptile, and marsupial) habitat requirements were researched. These habitat requirements (shoreline complexity, water depths, island size and distance from shore, food, nesting and roosting sources) were then interpreted into the lake design features of the precinct and constructed over a 10-year period.

To determine the flora species to be used in revegetation, extensive desktop studies and physical surveys were conducted to determine the species and composition which would encourage freshwater communities to re-establish. Individuals species were then selected on propagule availability, fauna requirements and historic success in re-establishment programs. Vegetation propagules were collected from tributaries taking careful consideration of the relevant ecotones and genetic variations. During the implementation phase an adaptive management approach was taken with monitoring of ecosystem services to modify or improve delivery.

This case study presents the lessons learnt over a 10-year period about re-establishing sensitive aquatic and riparian ecosystems in disturbed sites and the difficulties with in lake planting and ecosystem functions. The results of extensive monitoring shows evidence of significant biodiversity outcomes including the return of iconic aquatic wildlife species and mammals.

HYDROLOGICAL DRIVERS OF RIVER-FLOODPLAIN FOOD WEBS: IMPLICATIONS AND OPPORTUNITIES FOR OUTCOMES OF ENVIRONMENTAL FLOWS

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The structure and function of freshwater ecosystems are strongly influenced by hydrology yet there is little specific empirical evidence showing how river-floodplain trophic dynamics interact with hydrological regimes. Predicting the effects of altered or restored flow regimes on higher-order consumers such as birds and fish relies on documenting basal energy production and transfer through food webs. Existing models of river ecosystem function emphasise the importance of basal energy sources and inputs of material, yet often fail to account for the factors (including hydrological) which influence energy transfer through the food web. We synthesise existing literature to conceptualise how the hydrological regime influences both the production and transfer of energy through riverine food webs by focussing specifically on five distinct hydrological events: channel drying and rewetting, base flow, in-channel pulses, bankfull flow and overbank inundation. We propose a model conceptualising how hydrological regimes affect energy production and transfer in river-floodplain systems, both directly and indirectly. The model brings together six distinct hypotheses and generates a set of research questions essential for understanding the effects of hydrological regimes on food webs. We identify four key opportunities for further research to provide improved conceptual and empirical understanding of trophic dynamics in river-floodplain systems. An improved understanding of how the hydrological regime influences spatial and temporal patterns of production and the movement of energy through river-floodplain networks is essential to determine whether the restoration of flow regimes will achieve targeted ecological outcomes for high-order consumers.

PERFORMANCE OF TWO DIFFERENT MORPHO-ECOLOGICAL CYPRINIDS IN A FISHWAY WITH DISTINCT VERTICAL SLOT CONFIGURATIONS

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Properly designed vertical slot fishways (VSF) can restore longitudinal connectivity for potamodromous cyprinids and mitigate the impact of anthropogenic obstructions on watercourses, such as weirs and dams, that block the migratory pathways of these fish species. So far, knowledge about VSF design stems from numerous studies conducted on high priority anadromous species such as salmonids, whereas, potamodromous cyprinids, received comparatively much less attention. In Mediterranean rivers, where water limitation is a problem, effective low discharge fishways are desirable. Attempting to contribute to fill this gap, the present study focuses on the behaviour and performance of two Iberian cyprinids with different ecological traits, the Iberian barbel (Luciobarbus bocagei, Steindachner, 1864) and the Iberian chub (Squalius pyrenaicus, Günther, 1868). This study was conducted in a full-scale experimental VSF under two different slot configurations (C1 and C2), which require different discharges for equal mean water depths in the pools (Q=110 L.s-1, for C1, and Q=81 L.s-1, for C2). Results show that, the small-bodied water-column oriented chub, performed a higher number of upstream movements in C2, while for the barbel, a large-bodied potamodromous bottom-oriented fish, the performance was similar in both slot configurations. Overall, C2 is a more cost-effective design requiring a lower discharge to operate while serving both species. It is thus the best option, especially in regions affected by water scarcity.

RESTORATION PROBLEMS OF COASTAL LAGOON LAKES

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Coastal lagoon lakes are greatly influenced by external factors due to their position between freshwater and the sea. These systems are highly heterogeneous and dynamic. Estonian lagoon lakes have emerged not long ago in the geological time scale and are rapidly changing from marine communities to brackish, those to freshwater and in turn to coastal meadows. Mostly due to a shallow water column, the environmental conditions in the lagoon lakes are changing rapidly and that makes these ecosystems weak and sensitive to influences from climate change and eutrophication. The ecological status of these lakes is highly dependent on the influx of seawater during high tides and storms. These ecosystems are naturally enriched and very productive. Additionally, the sediment in these lakes often constitutes of easily resuspendable sediment, where a considerable amount of nutrients is accumulated. Thereby, the lakes may end up in crisis when the high amount of nutrients and/or organic matter and high productivity will lead to oxygen depletion. Poor oxygen conditions can cause degradation of water quality and impacts negatively the biota of the water body. In addition, the ecological status can furthermore exacerbate, when weather conditions are changing due to climate warming and storms come more frequent. Due to higher wind speed and waves, even more phosphorus can be mix up from the deeper sediment layers and add to the internal loading problem.

In order to decide for proper restoration methods, a sediment phosphorus study and incubation experiments were conducted with sediment cores collected from a coastal lagoon lake, Vööla meri (Northwest Estonia).

The analysis showed that a large amount of phosphorus has been accumulated in mobile forms and phosphorus is leaking from sediment to water column during resuspension or anoxia periods.

A large amount of phosphorus accumulated in the sediment can accelerate eutrophication and overgrowing of the lagoon lakes. Consequently, due to the climate change the lagoon lakes could be considered one of the most endangered water habitats of the world. Natural conservation and water management will inevitably have to address issues arisen with these water bodies – to maintain them as aquatic ecosystems or to allow the lagoon lakes to naturally come to overgrowing and swamping.

SELECTIVE FISH REMOVAL IS COST EFFECTIVE RESTORATION AND MANAGEMENT OF TEMPERATE EUTROPHIC LAKES

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Biomanipulation by selective mass removal of benthivorous and planktivorous fish, especially cyprinids, which benefit from eutrophication, maintain internal phosphorus loading and algal blooms, suppress biodiversity of waterfowl and have low/no commercial value, is of high potential importance in restoration of temperate lakes. It can improve the ecological status of lakes while the diffuse external loading tackled in agricultural policy declines slowly. Fish removal has been carried out in small and large (up to 155 km^2) Finnish lakes since the 1990´s by seines and fykenets developed from gear used in commercial fishing and adjusting fishing effort to the seasonal behavior of the target species. The short term removal has been up to c. 200-600 kg/ha/a in large vs. small lakes and long term removal up to 1.4 t/ha (76 kg/ha/a in 1997-2015) in a larger lake (6 km^2). Biomanipulation has improved water quality (transparency, nutrient concentration and chlorophyll-a), ecological status and economic value of the fish community. Maintaining removal with lower effort is needed to maintain the impact of restoration, or to prevent deterioration from good status, even at relatively low external loading. Fishing is cost effective phosphorus removal. The average cost paid to fishermen (< 1€/kg of fish f.w.) corresponds to 75-100 €/kg P. It is low compared with the average cost of reducing agricultural phosphorus loading. Linking biomanipulation with blue bioeconomy in restoration of temperate lakes could lower the fish removal cost close to self-supported action. Some SME´s in food industry already buy roach for 2 €/kg.

ECOSYSTEM DYNAMICS IN THE CONTEXT OF A LARGE RIVER RESTORATION BY CONTROLLED BANK EROSION (UPPER RHINE RIVER, FRANCE)

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Over the last two centuries, the Upper Rhine River (France, Germany) was subjected to important hydraulic engineering works which have severely damaged its functioning. Rectification, construction of groyne fields, damming and flow diversion induced hydro-morphological impacts that have contributed to greatly alter both aquatic and riverine biodiversity. These effects concerned the „Old Rhine" river, a 50-km long by-passed reach, located downstream of the Kembs dam. Given these functional deficits, a restoration action was carried out during 2013. It consisted of a controlled bank erosion and the construction of two artificial groynes directing the flow towards the bank. The purpose of this study was to assess ecological responses through a four-year control-impact study design with riparian/aquatic vegetation and macroinvertebrates as biological indicators. Changes in bedforms were defined with a score system describing habitats and a geomorphic analysis. The study demonstrated that artificial groynes reinforced the habitat heterogeneity that enriched aquatic and riverine biodiversity, with the appearance of species adapted to new depositional substrate areas coming from the bank erosion. This research was conducted in a context of multiple biological pressures that co-occurred with the restoration action, such as biological invasions and food web modifications. The ongoing global study to (i) highlight and dissociate biological responses to the restoration actions from the other major changes, (ii) assess the sensitivity of the new habitats to invasive species and (iii) improve knowledges on the relationship between geomorphology and ecology will be also presented.

ASSESSING THE SEASONALITY OF VANADIUM CYCLING AND SPECIATION IN A SHALLOW LAKE (KINGHORN LOCH, UK)

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Vanadium (V) is a toxic trace metal that is common in mining wastes released into aquatic systems via industrial leachates (e.g. red mud) and fossil fuel combustion. Though reportedly toxic to aquatic organisms, very little is known about V biogeochemistry within lakes. Here we present an analysis of a long-term data set (1954-2012) documenting recovery of V concentrations in a shallow lake (Kinghorn Loch, Scotland), 30 years following the diversion of red mud leachate. We examined evidence of persistent V cycling between bed sediments and the water column in recent years, specifically, assessing seasonal variation in total V (TV) and V speciation in surface waters. TV concentrations were highest in spring and were correlated with sulphate, chlorophyll α and total arsenic concentrations, indicating multiple potential cycling pathways. A thermodynamic model was employed to estimate the speciation of V within surface waters. Three species of V were identified: H(VO4)2-, H2(-VO4)- and NaH(VO4)-. Species composition varied significantly with season and was correlated with pH.

These results demonstrate the complexity of V biogeochemistry within aquatic ecosystems and highlight the legacy effects of industrial pollution on sensitive aquatic ecosystems. We provide novel insights into V cycling in lakes identifying both chemical and biological drivers. We present these data in the context of potential mitigation measures to address the legacy effects of industrial pollution of lakes.

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A NEW PARADIGM FOR BIOMONITORING: AN EXAMPLE BUILDING ON THE DANISH STREAM PLANT INDEX

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Despite intensive efforts for more than a decade to develop Water Framework-compliant assessment systems, shortcomings continue to appear. In particular, the lack of reference conditions has hindered the development of assessment systems capturing the heart of the WFD – that ecological status should be set as the deviation from the natural, undisturbed condition. Recently, the Danish Stream Plant Index (DSPI) was developed. This system contrasts existing systems in that it builds on an expert interpretation of the normative definitions of ecological status classes in the WFD without taking pressure-impact relationships into account. Here we present a paradigm for biomonitoring exemplified by DVPI that build on a framework consisting of three separate steps. First an ecological assessment should be conducted applying DVPI, then causes of failure to meet ecological goals should be explored by investigating trait composition of the aquatic plant community and finally mitigation measures should be selected that specifically target the identified causes of not meeting the ecological goals. Applying this framework enables managers to target the overlying stressor first. In Danish streams eutrophication and modifications of the stream planform together with frequent management in terms of weed cutting constitute major stressors. Targeted mitigation actions in Danish streams are therefore to 1) stop or reduce weed cutting, 2) restore in-stream or border habitats and 3) reduce nutrient emissions. These mitigation actions can be applied alone or in different combinations depending on the overlying stressor identified from plant trait composition.

QUANTIFICATION OF CHAOBORUS BY MOBILE UPWARD-LOOKING ECHOSOUNDING

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Mobile hydroacoustic upward-looking transducers were used to search invertebrate in upper layers of artificial lake in the Central Europe. Acoustic scattering mainly from Chaoborus larvae and juvenile fish was studied using two split-beam transducer 120 and 38 kHz. Ichthyoplankton trawl was used to identify natural composition of both groups at two different depths 0-2 and 3-5 m. In the targets strength range corresponding to invertebrate apparent peak was found at TS -66 and -64 dB (120 kHz). This range corresponds to average size of Chaoborus mainly caught by ichthyoplankton trawl. The correlation between volume density of Chaoborus established from direct sampling and acoustic recording was high (r<0.73), nevertheless, the correlation was significantly different from 1:1 line.

A NOVEL UPWARD-LOOKING HYDROACOUSTIC METHOD FOR IMPROVING PELAGIC FISH SURVEYS

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Information about fish distribution and abundance in the upper layer is often fundamental. However, this information is extremely hard to obtain using hydroacoustic methods. Mobile hydroacoustic upward-looking transducers provide a unique option to survey the upper layers of lakes. We developed a rigid frame system pushing the upward looking transducers of the scientific echo sounder (38 and 120 kHz) in front of the research vessel. The efficiency of the new acoustic approach for monitoring juvenile fish at night was investigated by comparing the results with a quantitative fry trawl in the Římov Reservoir in the Czech Republic. The experimental setup enabled comparisons for the 0-3 m and 3-6 m depth layers, which are utilized by almost all juvenile fish in the summer. No statistically significant differences in the estimated abundance of juveniles were found between the two sampling methods, and the estimated length distribution was similar for both methods.

EXPLORING THE POTENTIAL USE OF HYDRO-DRONES FOR FRESHWATER MUSSELS SURVEY

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Long-term monitoring of freshwater taxa is usually hampered by expensive and time-consuming visual surveys. This is the case of freshwater mussels that are rapidly declining due to ecosystem alterations worldwide. Important basic information on them (distribution, habitat preferences, ecophysiological constraints) are scarce. Unfortunately, the possibility to acquire this basic information is impeded by inadequate funding. Exacerbating this problem is the difficulty to track and observe freshwater mussels, because they are often rare and clustered. In addition, mussel surveys are often hampered by restrictive environmental conditions. Although the choice of an appropriate sampling design can improve the likelihood that a survey meets its goals, there is no sampling design that can correct an access problem. To escape this bottleneck we started exploring the potential use of hydro-drones, developed for this purpose by a recently created start-up company. Hydro-drones are regarded as beneficial tools for obtaining data that cannot be accessed otherwise. However, to date their use for research, monitoring and protection of species surprisingly still not consider them.
A pilot project, assessing the efficiency of hydro-drones and their application limits under gradients of environmental constraints, was developed to survey mussels in the recently recolonized Lake Orta.

THE IMPACT OF MELTING PROCESSES ON MACROBENTHIC COMMUNITIES WITHIN AN ALPINE HEADWATER STREAM

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High alpine catchments are characterized by significant variations of meteorological conditions in space and time, complex hydrogeological situations and heterogeneous snow cover dynamics. Typically, alpine streams lead to large increases of runoff rates during the melting period, in spring and early summer. Even minor changes of the environmental conditions can have significant consequences on biological communities. Although numerous small alpine valleys are still often not investigated at all from the zoological point of view.
The main objective of this research is to assess the effects of climate change and in particularly of the melting period on the macrobenthic community of the Saldura Stream (BZ). This perennial glacier alpine stream is located within the Central Alps (South Tyrol, Italy). The whole catchment (ca. 100 km2) belongs to an LTER-site. Three sampling stations are monitored since 7 years monthly during the snow free period (April - September). The biological analysis allows to determine taxa distribution patterns along an altitudinal transect of a glacier stream and their changes in space and time. The results show that 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. Longitudinal as well as seasonal distribution patterns of macroinvertebrate communities are evident. In particular, the increasing discharge due to the snow- and ice melting corresponds to a decreasing trend of total faunal density and number of taxa.

PHENOLOGICAL MONITORING OF SUBMERGED MACROPHYTES: THE CASE OF CHAROPHYTE SEXUAL REPRODUCTION FROM SHALLOW MEDITERRANEAN PONDS

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Since vegetative propagation is extended in submerged macrophytes, little attention has been paid to timing of sexual reproduction. However, some macrophytes -such as charophytes- can produce drought resistant propagules that are relevant in shallow and temporary ecosystems from Mediterranean areas.
We monitored and analysed the reproductive phenology of three species of charophytes that grew in two brackish shallow ponds within the Albufera de València Natural Park (Spain) that differed in salinity. Chara hispida (Ch), Chara aspera (Ca) and Nitella hyalina (Nh) grew along the shores of one of the ponds (< 0.5 m depth). Ch was the dominant species in both ponds and grew also in deeper conditions. Samples were taken biweekly/monthly during 2014 and 2015 for the detection of sexual organs. Seasonality on the different phenophases (unripe/ripe gametangia, ripe oospores) was formally described and compared by applying circular statistics.
All species had a seasonal reproduction, with most of the shoots producing sexual organs during spring and summer, but showing species-specific patterns. Phenology did not differ significantly between the two studied years, except for Ca, that showed a second reproductive peak in autumn (only for 2015). A tendency in delaying reproduction when increasing depth was observed for the dominant species, whereas no large changes were found due to salinity differences between the two ponds.
Unequal patterns between species could be explained by their different life cycles, including breeding system (monoecy/dioecy). Specific environmental requirements and tolerances in charophytes also induced distinct development times when coexisting within the same ecosystem.

USING ENSEMBLE MODELS TO DEVELOP A FISH-BASED INDEX OF GUIANESE STREAMS BIOTIC INTEGRITY

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Highly sensitive ecosystems such as freshwaters require the development of reliable and effective monitoring tools. Such tools, however, are missing in tropical environments that host high biodiversity, and are increasingly disturbed by human activities.
Here we developed a fish-based index to assess the effects of human disturbances on Guianese streams. We modelled fish occurrence using an ensemble modelling approach that includes 6 modelling methods. Ensemble models are widely used in macroecological studies of global change impacts on species distribution, but not yet into water quality assessment procedures.
Using Ensemble models enhanced model predictive power and permitted the integration of a substantial part of the fish species into the biotic index calculation. Moreover, higher taxonomic levels (genera and families) were also considered to integrate rare species into the biotic index calculation. Indeed, tropical faunas are particularly rich in rare species covering unique functions. Therefore, they deserved to be considered in ecosystem integrity assessment.
We modelled the occurrence of 41 taxa in 251 stream sites. Twenty-one taxa were sensitive to human disturbances (gold-mining and logging). Their ecological traits (habitat, trophic guild, position in the water column) were used to calculate a multimetric index.
This index correctly classified sites according to their disturbance effect for more than 70% of the sites, revealing that our multimetric index can constitute a relevant tool to detect gold-mining and logging effects on Amazonian streams. This is of particular importance given the current intensification of threats to the Neotropical streams.

WHAT DRIVES THE INTERANNUAL VARIABILITY IN FISH-POPULATION TIME SERIES?

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Assessments of fish population in large environment are highly challenging and extremely expensive. Indeed, fish populations are estimated using repeated counts (electrofishing, net catches) characterized by a strong over dispersion that provide uncertain estimates of actual densities. Previous studies showed that fish-population time series allow detecting significant trends and shifts linked to continuous and sudden environmental changes (caused by global warming, anthropogenic alterations and restoration actions). However, those ecological time series exhibited also a high interannual variability still poorly understood. In this study, we proposed to use symbolic dynamics approach combined with techniques from Information Theory to identify the processes that drive the strong interannual variability in fish-population time series. We analysed four extensive data sets (fish populations in 40 streams, the Rhône River, the Gironde estuary, and in the Bay of Biscay) characterized by relatively long-term ecological time series (~ 30 years) and including a detailed description of the environmental conditions. We transformed continuous environmental and ecological time series into symbolic sequences based on the time series trajectory at each time-point and calculated the mutual information between symbolic sequences to evaluate the degree of synchrony between time series. We expected synchronisms between 1) fish populations of the closest sites, 2) juveniles and adults, 3) environmental drivers and fish densities. A lack of significant results for these three evident hypotheses might suggest a too important sampling noise to be able to examine the variability in fish populations at the interannual time scale and a reconsideration of these costly extensive fish samplings.

SENSING LIKE A FISH USING AN ARTIFICIAL LATERAL LINE PROBE

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Lateral line probes are a new type of bio-inspired sensing device for ecohydraulics flow measurement and classification. The probes are based on fishes highly evolved octavolateralis flow sensing capabilities. The device consists of a time synchronized array of rapid pressure sensors installed over a probe body. In contrast to point measurements, the lateral line probe provides a new source of simultaneous data in both space and time. This approach provides ecohydraulics researchers with new sources of flow information as (i) the fluid-body interactions are considered and (ii) the sampling rate is higher than any other field tool (tested up to 200 Hz), bringing the measurement closer to the “fish’s perspective”. We present a new generation of LLPs based on differential pressure sensors able to overcome some of the limitation of previous probes. Specifically, we show that it is possible to mechanically filter the static component of the pressure from the dynamic, and how to increase of sensitivity by more than ten times (0.0678 Pa/bit) independently of the depth. In order to demonstrate its performance, the LLP has been evaluated in a laboratory flume as well as in an experimental fishway under diverse hydrodynamic environments in the range of expected in real-like conditions. Likewise, in order to show that LLPs are an interesting alternative for the study of natural flow fields, probe data is compared with observations of fish behavior in an experimental vertical slot fishway.

AN ADEQUATE TOOLBOX FOR LONG-TERM MONITORING IN ALPINE RIVER ECOSYSTEMS

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Alpine river ecosystems are under increasing threat from various stressors. Climate change, for example, is predicted to cause direct and indirect effects to these systems and the flora and fauna they support. Alpine rivers are particularly sensitive to climate change because hydro-ecological processes respond to even small changes in climate and alter ecosystem properties and function. We argue that a sound assessment of these impacts is needed and that it requires several key elements. For a long-term monitoring program in the Hohe Tauern National Park in the Austrian Alps we have been studying environmental conditions, nutrients and benthic invertebrates in glacier-fed and spring-/groundwater-fed stream segments in four glaciated catchments. Along with the recording and measuring of hydro-ecological conditions we evaluated the quality and adequacy of specific indicators, considered to be necessary in such monitoring programs: i) from available abiotic and biotic data we modelled a prognosis of benthic macroinvertebrate assemblages, their abundances and diversities, ii) we elaborated new data in the monitoring sites, and iii) compared results from i) and ii) in order to find out relevant and adequate tools and indicators for climate change effects in alpine river ecosystems. These comparisons showed that most measures fell into the amplitudes of proposed values and therefore proofed that defined and implemented measures in our alpine river monitoring program were relevant and meaningful. As a conclusion we provide a conceptual model for cause-effect relationships of environmental conditions and ecosystem properties expressed by biotic indicator patterns and behavior.

SUB-CATCHMENT CONTROLS ON MACROINVERTEBRATE ASSEMBLAGES IN ALPINE STREAMS: THE ISSUE OF WHEN TO SAMPLE

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The seasonal dynamics of macroinvertebrates in Alpine streams are generally understood. However, this understanding remains under-developed and is rarely taken into account in indices used in monitoring programs. For instance, streams differing in environmental conditions in a basin may have different temporal variability in macroinvertebrate characteristics and thus affect potential indices for monitoring. In Switzerland, e.g., the IBCH index incorporates broad altitudinal bands that define when sampling should be undertaken, but does not fully account for environmental differences among streams within a band. Thus if streams in a band are sampled at the same time, assemblage differences between them may be as much due to sub-catchment controls on environmental variability (e.g., when the stream is environmentally favourable for particular life stages) than from differences in human impacts. To assess this hypothesis, the main drivers of macroinvertebrate abundance and diversity were examined for 14 tributaries (i.e., sub-catchment approach) in the Arolla basin, Switzerland, that environmentally differed. Physical measures and macroinvertebrates were sampled in August/October 2015, and monthly between May/October 2016, to quantify temporal variability. Data analysis suggests the need to identify assemblage response times in each sub-catchment that allows meaningful inter-stream comparison. Because of inter-annual variability in climate, we note these relative times may need to be shifted “in block” forwards or backwards in a particular year to account for temporal changes in environmental ‘windows of opportunity’ for organism life cycles. Alpine streams are notably complex and this complexity must be incorporated in long-term monitoring programs to ensure better understanding.

A NEW DATA MINING APPROACH TO UNDERSTAND THE RIVER ECOLOGICAL STATUS: FIRST LARGE APPLICATION OF CLOSED PARTIALLY ORDERED PATTERNS ON FRENCH AQUATIC DATA

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The French National water quality monitoring network has been renovated to assess the ecological status of rivers according to the European Water Framework Directive (2000). Chemical parameters and biological indices are regularly collected from 1800 locations in Metropolitan France since 2007. In the Fresqueau project context (nov. 2011- apr.2015, supported by the French National Research Agency, http://engees-fresqueau.unistra.fr/presentation.php?lang=en), we implemented a specific data mining process to explore the relationship between biological responses and potential chemical pressures from these data. The process generates closed partially ordered patterns (CPO-patterns) (Fabregue M., 2014). A pattern is a succession of chemical events that precede a biological status assessment for a given station. We studied patterns and their occurrence. We reported here the main interests of this tool: (i) it is rapid and efficient, (ii) CPO-patterns always gave coherent results between chemical and biological states, (iii) innovative results were revealed. For example, chemical statuses were often better than biological statuses suggesting synergism between toxicants and/or an additive impact of other pressures related to hydromorphology or hydrology. Another novel result is that depending on the biological index chosen, chemical parameters in the CPO-pattern varied. This suggested a differential sensitivity of the biological compartments to different chemical pressures. These results open promising perspectives to improve our understanding of the status of rivers, by using CPO-patterns on water data. . This work was funded by ONEMA (the French National Agency of water and aquatic ecosystems).

HABITAT USE OF MACROINVERTEBRATES IN MOUNTAIN STREAMS OF THE EUPHRATES BASIN (TURKEY)

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Hydro-morphological characteristics such as the structure of substrate in the river bed determine habitat diversity and often invertebrate diversity as well. Due to a rapid economic development in Turkey, there is intensive anthropogenic pressure on aquatic habitats such as the construction of dams, artificial embankments and channel straightening. This development results in a dramatic loss of natural stream habitats and their typical benthic communities.

To consider this chance, we analysed the habitat use of benthic macroinvertebrates of four natural and four anthropogenic affected streams in Eastern Turkey. To evaluate the habitat use of typical stream organisms, we calculated a “habitat score” describing the strength of habitat preference.

Lithal, xylal and living roots seemed to be especially important habitat types in the studied natural streams. First results show clearly that tolerant taxa such as chironomids occur in all habitats, whereas sensitive taxa such as Hydraena spp., Rhyacophila s. Str. or Ephemerella sp. (habitat scores >4) were often found in xylal and living roots. In the anthropogenic affected streams xylal/livings roots are scarce or unavailable. If they were present, they were inhabited by more opportunistic taxa of the Ephemeroptera and Trichoptera (e.g.Baetis spp., Caenis macrura, Hydropsyche spp.).

The results strongly suggest that habitats such as xylal/living roots in the natural streams are inhabited by specialists and have therefore a high significance for the ecological quality. In order to develop region specific indicators of ecological stream quality, the relationship between the occurrences of habitat specialist and anthropogenic effects are analysed.

MONITORING THE EFFECTS OF DEEP IMPOUNDMENTS ON WATER QUALITY OF A SMALL RIVER

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We investigated the effects of river regulation on nutrient, phytoplankton and oxygen dynamics in the 92 km long, heavily impounded German section of the Saar, a relatively small river (MQ = 80 m3 s-1) that was reconstructed to ensure navigability. This section of the Saar is regulated by six weirs of up to 14.5 m height. Our study focusses on the longitudinal dynamics of water quality parameters along the river course, and on vertical stratification in the deepest weir pools. We present a vertical mobile probe device to gain continuous data of temperature, oxygen and chlorophyll a content at different water depths from 2014 and 2015. In spring, phytoplankton blooms usually developed in the more upstream river reaches and propagated downstream leading to chlorophyll a concentrations between 30 and 60 µg L-1, while summer phytoplankton peaks of up to 70 µg L-1 diminished occasionally during downstream transport because of zooplankton grazing or discharge variation. Pronounced vertical gradients in chlorophyll a of more than 50 µg L-1 difference between top and lower water layers were observed in the deepest weir pools. These gradients in phytoplankton distribution occurred especially during thermal stratification events in summer. Oxygen concentrations in lower water layers decreased several times below 4 mg L-1 for a period of more than 6 consecutive days. The parallel monitoring of longitudinal and vertical variation in water quality provides a high-resolution image and reveals the strong impacts of impoundments on water quality.

RIPPLE EFFECT: EXPANDING EDNA MONITORING IN PONDS FROM GREAT CRESTED NEWT TO WHOLE VERTEBRATE ASSEMBLAGES

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Environmental DNA (eDNA) analysis is a rapid, cost-effective, non-invasive biodiversity monitoring tool which utilises DNA deposited in the environment by organisms for species detection. The method is a recognised species-specific survey tool for rare or invasive species in a broad range of ecosystems but combined with 'metabarcoding', eDNA can reveal community structure from environmental samples. However, this method of mass species detection can fail to detect rare or cryptic species. The sensitivity of eDNA metabarcoding was compared to targeted real-time quantitative PCR (qPCR) for great crested newt (Triturus cristatus) detection in UK freshwater ponds. Extracted eDNA samples (N = 532) previously screened by qPCR were re-analysed for all vertebrate species using high-throughput sequencing technology. eDNA metabarcoding (34%) and qPCR (36%) had comparable sensitivity for T. cristatus detection but application of conservative read-depth thresholds reduced metabarcoding detection (28%). The proportion of sequences identified as T. cristatus in each sample was positively associated with qPCR score (number of positive qPCR replicates) but negatively correlated with eDNA concentration of samples. eDNA metabarcoding detected a wealth of vertebrate biodiversity alongside T. cristatus, enabling the identification of species associations between vertebrate species in and around ponds. Additionally, environmental metadata was applied to eDNA metabarcoding species inventories to reveal predictors of T. cristatus pond occupancy and overall pond species richness. eDNA metabarcoding holds enormous potential for holistic biodiversity assessment and routine freshwater monitoring. We advocate this community approach to freshwater monitoring to guide management and conservation, and generate targets for species-specific survey.

DEVELOPMENT OF STREAM BIOMONITORING TOOLS FOR THE ECOLOGICAL MANAGEMENT OF LAKE KINNERET CATCHMENT (ISRAEL)

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Lake Kinneret (the Sea of Galilee) is the only large natural freshwater lake in Israel. The lake and its watershed support numerous ecosystem services, such as freshwater supply, fishery, recreation and tourism. While water quality and quantity are regularly monitored, there is presently no biological assessment of the streams and rivers in the catchment.
Here we present results from the ESSESSMENT project (supported by the German-Israeli Foundation) aiming to develop the first biomonitoring scheme in Israel, for the ecological assessment of Lake Kinneret catchment.
The project follows a structured methodology, comparable to the EU-WFD: a) development of stream typology; b) identification of a stressor gradient; c) macroinvertebrate analysis (combining traditional and genetic tools); and d) selection of relevant biotic indicators.
Overall, we identified nine stream-types to correspond with four sub-regions: Calcareous Streams and Mountain streams of the Hermon Basin and the Eastern Galilee; Basaltic Streams of the Golan Heights; Organic/Fine-substrate Streams of the Hula Valley, and three distinct sections of the Upper Jordan.
Fifty reaches (23 streams) across the catchment were sampled for invertebrates. Sites differ by altitude, type and intensity of environmental stressors. The composition of key invertebrate groups such as EPTs, coleopterans, dipterans and molluscs were found to be in good agreement with designated types. In addition, some species (e.g. belonging to Hydropsychidae, Elmidae and Hydrobiidae), are reported for the first time in this region.
Reference assemblages will be further used to set biotic benchmarks for determining the ecological status of streams in the Lake Kinneret catchment.

BIOLOGICAL EARLY WARNING SYSTEM BASED ON THE VALVE MOVEMENT BEHAVIOR OF UNIO TUMIDUS

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The standard monitoring of tap water quality base on physical and chemical methods. They are usually time concuming and single quality test can takes a few hours to determine most of compounds like nitrites, nitrates, iron, manganese, sodium, potassium etc. Moreover, chemical methods do not allow for continuous pollution control and the water quality can not be always guarantied. On the other hand, biological early warning systems (BEWS) can provide a permanent pollution measurenment and analysis based on the monitoring of a physiological or a behavioral function. Time of response depends on type of organism used in BEWS. The most of systems are based on bivalves behavior.
The study was carried out to verify the operation of the Polish biological early warning system SYMBIO. Research was carried out on the valve movement behavior of bivalves. Behavior is controlled in real-time and interpreted by the software. Three substance were checked – nitrates, ammonium and sulfates. The maximum concentration has been selected based on the Polish regulations. The valve movement, time of activity and frequency were checked. The results have confirmed the rapid bioindication reaction of molluscs on testing substances. Moreover, it was revealed that various substances induce variable behaviour pattern of mussels

Key word: Unio tumidus, BEWS, biomonitoring,

LONG-TERM CHANGES IN ZOOPLANKTON CRUSTACEAN ASSEMBLAGES IN THE DANUBE FLOODPLAIN AREA (SLOVAK-HUNGARIAN STRETCH)

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The study reports on results on zooplankton crustacean assemblages of Danube Floodplain on the left-bank floodplain, between river km 1841 and river km 1804. The structure of planktonic crustacean assemblages has changed since the hydropower plant was put into operation in October 1992. Great changes have been observed in the previous parapotamal side arm, now artificially fed with water from the head-race canal. Three characteristic groups of planktonic crustaceans assemblages were recorded when a different habitat was taken into consideration. Euplanktonic species prevailed of all sampling sites before damming. In the period after damming, littoral species dominated on the main channel sampling sites. In parapotamal and plesiopotamal side arms with the rich littoral macrovegetation during periods after damming, phytophilous species were the ones with the highest occurrence. The work aimed to quantify the cladocerans and copepods habitat preferences. Of 121 crustaceans 40 taxa showed preference for eupotamal habitats, 42 species preferred eupotamal B/parapotamal, and 49 taxa were found to prefer the plesiopotamal/paleopotamal habitat type. Identified habitat types follow a gradient of hydrological connectivity with the main river channel, ranging from the eupotamal to more or less isolated floodplain water bodies. We tried to find a relationship between the long-term of data of Cladocera and Copepoda communities the hydrological connectivity. Both groups have proved as good indicators detecting the changes in fiver-floodplain system. Calculated floodplain index values indicate the extant of disruption to lateral connectivity of the floodplain area. The study was supported by VEGA 1/119/16.

MONITORING OF LARGE DEEP LAKES IN NORWAY - WITH GLIMPSE FROM THE ZOOPLANKTON COMMUNITIES

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The large deep Norwegian lakes are among the deepest in Europe with Lake Hornindalsvatnet as the deepest on the continent. There are many differences between these deep large lakes and smaller more shallow lakes. They usually have longer residence time and contain a large cold, often oxygen rich, hypolimnion. In many of the deep lakes in Southern Norway a glacial relict fauna depends on this oxygen rich deep water habitat to survive. The deep lakes supply important ecosystem services, but they are also under strong anthropogenic pressures. Nevertheless, in Norway there is relatively little data available for the large deep lakes (> 50 km2 and/or > 100 m depth) compared to smaller ones. For example Norway have had a national monitoring of smaller lakes since the 1980'ies, but monitoring of the large deep lakes at a national scale only started in 2015 (surveillance monitoring c.f. WFD). Here, we will introduce the national monitoring program for the deep large Norwegian lakes. Seven lakes were sampled in 2015 and additional six lakes were included in 2016. The monitoring include sampling of physics, water chemistry, phytoplankton, crustacean zooplankton and fish in the pelagic zone as well as benthic macroinvertebrates, littoral microcrustacenas and macrophytes in the littoral zone. We will present some of the main physical, chemical and biological results from the pelagic sampling in 2015. We will also highlight some faunistic differences and similarities between the deep large lakes and smaller lakes by comparing the zooplankton communities.

THE PARADOX OF EXPERT JUDGMENT IN RIVERS ECOLOGICAL MONITORING

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A large effort has been made in the development of quantitative methods to classify the ecological quality of rivers. Yet, in spite of all attempts to avoid subjectivity, expert judgment is still used at numerous steps of the ecological classification and is often considered as indispensible for management purposes. Here we tested the hypothesis that expert judgment could result in the same classification of indices but quicker and cheaper. We compared the classifications (on 13 aspects of rivers) attributed by two experts to 20 sites (10 each) located in their study areas, with the classifications of ecological quality based on biological indices (invertebrates and diatoms), hydromorphology and water chemistry, calculated by an independent team. Assessments were globally very similar (RELATE: Rho=0.442; p<0.001) and most differences were of one class, with experts attributing a better condition than indices to the best quality sites but a worse condition to the worse quality sites. A PCA revealed that sites to which experts attributed a moderate quality had higher nitrate concentration and pH but were well oxygenated. Experts‘ evaluations on hydromorphological conditions of the channel and margins are also significantly correlated with the quality assessments made by a field team with no experience in the study area (Rho=0.518; p=0.001), indicating geographic independence in the expert judgment. We concluded that expert judgment could be used in the assessment of ecological quality, helping to redirect monitoring funds to actual implementation of restoration measures. Classification’ methods may still be useful for a better targeting of restoration measures.

ESTABLISHING REFERENCE CONDITIONS FOR LAKES AND STREAMS: COMPARISON OF SPATIAL AND MODEL-BASED APPROACHES

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Spatial typology and models and are two approaches commonly used to partition natural variability, and ultimately gauge anthropogenic effects on biodiversity loss and other valued ecosystem services. Using benthic invertebrate assemblages of boreal lakes and streams, we tested the efficacy of spatial typologies and modelling for partitioning natural variability of sites judged to be in reference condition. We predicted that species distributions and assemblage composition would be more accurately predicted by models in general and specifically that models based on suites of predictor variables (full models) would outperform models based on a limited number of variables. Furthermore, we predicted that more flexible typologies (System B typology) would perform better than approaches using sets of mandatory categorical variables (System A typology). Models were more accurate at estimating species distributions and composition and had lower incidences of false positive errors than spatial approaches. Furthermore, models calibrated with only a few typology-based variables were as accurate as full models, indicating that the main environmental gradients were covered by the variables used in delineating lake and stream typologies. Models also had lower incidences of false positive error compared to typologies. The findings that models outperformed spatial approaches and that the latter had substantially higher frequencies of false positive errors (i.e. erroneously classifying reference sites as impaired) is somewhat disconcerting for management and can result in unwarranted use of resources to reject potential misclassification, or more seriously implementation of unnecessary rehabilitation.

A ~30-YEAR BIOMONITORING RECORD OF DIATOM COMMUNITY DYNAMICS IN A POLLUTED LOWLAND UK RIVER

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It is widely accepted that climate change will increase the frequency and intensity of weather events such as droughts and flash floods that will affect stream hydrology, sediment dynamics, and the mobility and concentration of pollutants. How these changes will impact biological communities in historically polluted systems is poorly understood, especially over longer timescales. Yet the community dynamics over time are key to establishing the 'ecological status' of surface waters. Assessing current 'status' is a requirement of the Water Framework Directive, and integral in determining the effectiveness of historic and current restoration or mitigation measures. Here we present preliminary results from a long-term, sub-seasonal resolution (~2-4 monthly samples collected over ~30 years) monitoring project of periphytic diatom communities in an English river, the River Derwent, Derbyshire, an historically important waterway in terms of its industrial revolution heritage. This dataset (1988-present) represents a unique continuous biomonitoring record during a period of improved water management practices. By analysing diatom community dynamics over such a timescale, we aim to provide a better understanding of how a polluted river responded to different hydroclimatic drivers at a variety of timescales, and how the communities track recovery towards improved ecological status. We also explore methodological aspects of assessing ecological status such as colonisation rate and the effect of different substrate type, and how biotic indices (such as the UK's Trophic Diatom Index or TDI) perform as tools to describe community change over such relatively long timescales.

APPLICATION OF A PREDICTIVE FISH INDEX OF BIOTIC INTEGRITY (IBI) IN NEW ZEALAND

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The Index of Biotic Integrity (IBI) was originally developed using fish in the USA by James Karr during the early 1980s. The original version had 12 metrics that reflected fish species richness and composition, the number and abundance of indicator species, trophic organization and function, reproductive behavior, fish abundance, and condition of individual fish. This process has been repeated and IBIs developed on many continents. The fish fauna of New Zealand is however radically different from the continental faunas in having a single trophic level and very high proportions of diadromous species thus the IBI developed for New Zealand described this presentation has a number of novel variations from the original Fish IBI. The differences include the proportion and abundance of species specializing in different habitats, thus is more of a functional assessment. However, the basic concept of applying a number of metrics to assess fish assemblage condition and the use of a large number of sites to give a regional background level of biological integrity and then comparing a site of interest with that dataset to assess the status of the test site has been retained in this New Zealand IBI.

ROTIFERS OF INTER-FOREST SPRINGS

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Rotifer fauna of 48 springs of the Knyszyn Forest (North-eastern Poland) was surveyed in summer and autumn 2014-2015. Rotifer densities in the springs were relatively low in summer, i.e. up to 10 ind. L-1 of Monogononta and 22 ind. L-1 of Bdelloidea. Similarly low they were in autumn, up to 42 and 10 ind. L-1, respectively.
Mean number of monogonont species per a spring was very low both in summer (6 ± 5) and autumn (9 ± 6). Nevertheless, the total number of species recorded in all springs under study was relatively high and accounted for 101 ones, 79 in summer and 62 in autumn. Although strongly differentiated, rotifer fauna contained a set of several species common to most of the studied springs. These were: Colurella adriatica, Lecane closterocerca, Lepadella acuminata, Trichocerca taurocephala in summer communities and C. adriatica, L. acuminata and Lepadella patella in autumn ones.

GETTING MORE OUT OF STREAM MONITORING DATA WITH GEOSTATISTICAL MODELS

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Phyisco-chemical and biological monitoring can only be conducted at a limited number of monitoring sites while these observations serve as proxies for the status of the whole river network. However, typically the statistical analysis of such monitoring data ignores the spatial arrangement of the monitoring sites that are partly connected via the stream network. Hence, on the one hand valuable information from connected sites is disregarded and on the other hand observations are wrongly treated as independent. In this presentation, we illustrate how more information can be gained from typical monitoring data with geostatistical regression models.
Using monitoring data collected by the French and German authorities, we investigate the role of land use characteristics, topography and other factors on different spatial scales for determining pesticide and nutrient exposure as well as invertebrate community structure in streams. We apply a method that incorporates spatial autocorrelation of measurements (Peterson & Ver Hoef, 2010). First, we describe the harmonization steps necessary for joint analysis of the different data sets and present an R package for GIS data preparation (openSTARS). Then, we exemplify the application of geostatistical regression models, analyse the quality of such models for the different monitoring regions and evaluate spatial predictions on the river networks. Finally, we discuss how monitoring networks can be optimized and where additional monitoring sites would yield the highest gain in information.

RECOVERY OF SOFT-BODIED BENTHIC ALGAL ASSEMBLAGES FROM ACIDIFICATION IN CZECH HEADWATER STREAMS ACROSS THE GEOMON NETWORK

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Anthropogenic acidification has adversely affected freshwater ecosystems in Europe. Chemical recovery commonly involves increses in water pH and decreases of Al and heavy metals, but is often interrupted by short-term acidic high-flow events. Acidification and eutrophication are among the major stressors on freshwater ecosystems. Fifteen streams of the Czech GEOMON network of forest catchments (Oulehle et al. 2017, Biogeoch., in press) were sampled in order to study the effects of water pH, Al and Pb, short-term acidic events, two decades of acidification recovery, and high P concentrations combined with low pH on soft-bodied benthic algae. Results indicate that water pH and Al concentrations affected benthic algal assemblages, but that the acidification index periphyton AIP (Schneider & Lindstrøm 2009, Ecol. Indic. 9: 1206) first and foremost reflects stream pH. Benthic algal assemblages reflected recent acidic events more closely than long-term average pH; our results are consistent with the assumption that the reaction of benthic algae to pH is a result of two processes: (1) a fast effect of pH minima that cause sensitive species to disappear within few months, and (2) a slower process of dispersal and competition for resources during baseflow periods of higher pH. Granitic Lysina catchment with low streamwater pH and simultaneously high P concentrations had an acidic, not a eutrophic, benthic algal assemblage. Therefore our data indicate that acidification may mask the effect of enhanced P concentrations on benthic algae. This could suggest that recovery from acidification may entail increased eutrophication (Schneider et al. 2017, in review).

ESTABLISHMENT OF A NATIONAL TYPOLOGY FOR THE ECOLOGICAL STATUS ASESSMENT OF RIVERS IN GREECE

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Typology and type specific reference conditions are essential for the determination of the Ecological Quality Ratio (EQR) values of metrics/indices used for the assessment of ecological status. In Greece, four typological systems have been used [System A, the Mediterranean Intercalibration RM, the 1st River Basin Management Plans' system (RBMP), and the Northern and Central Greece system (B')]. To investigate the most appropriate system, Discriminant Analysis (DA) was applied on benthic macroinvertebrate data as independent values and, the types of the different typological systems as grouping values. For the establishment of reference conditions, a vast number of selection criteria based on land use, hydromorphological, physico-chemical parameters and biological quality, were used forming five data sets ranging from at least disturbed to more disturbed sites. DA was applied to the four typology systems using all data sets although the three latter systems had weaknesses (i.e. limited reference samples to estimate EQR, not covering small river catchment size (<10Km2), etc.). A higher accuracy was found in all typological systems as to the original grouping of the types using the data set with the least disturbed sites. RBMP typology system had the highest original and cross-validation grouping, but monitoring reference samples were not enough per type and shapefiles provided did not cover the whole country due to the lack of parameters used in this system (e.g. annual runoff and rainfall, evapotranspiration and runoff index). Therefore, the Mediterranean intercalibration RM typology, having the next highest accuracy and being the most efficient, was chosen for Greece.

ESTABLISHMENT OF A NATIONAL BIOTIC INDEX FOR THE ECOLOGICAL STATUS ASSESSMENT OF RIVERS IN GREECE

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The intercalibrated Hellenic Evaluation System 2 (HESY2) is the ratio of an observed value of HESY to the median reference (expected) values of the same Mediterranean Intercalibration river type (RM), referring to the abundance and diversity/richness of benthic macroinvertebrates (family level) and their tolerance to pollution, being standardized against the habitat diversity richness. To develop HESY2, 29 European biotic metrics and the indices STAR ICMi, ASPT-2, HES, AHES, SemiHES were applied to the Greek data. To choose the most appropriate metric/index, the following were tested: a) their response to three quality gradients (unimpaired, slight impaired, impaired) using box-and-whisker plots of their distribution as to the overlap of their median, b) a low coefficient of variation (< 1) and c) a low Spearman's correlation between the metrics/indices. Four metrics (%ERTC, Shannon, Evenness, SemiHES) were selected to form three new polymetric indices. Apart from them, STAR ICMi, HESY2 and three modifications of STAR ICMi (instead of the metric ASPT-2 was used HES, AHES and SemiHES) were tested. Initially, the quality boundaries were calculated using box-and-whisker plots to the normalized values setting the High/Good (to the 25% of the reference values) and Good/Moderate quality boundary. Comparison of all indices was then performed through Discriminant Analysis (DA) in all RM types applied to benthic macroinvertebrates as independent values and quality boundaries as grouping in order to find out how many samples have shifted from moderate to high and good quality (major importance for the WFD). The least shifting was found in HESY2.

WATER MITES (HYDRACHNIDIA) IN MACROINVERTEBRATE-BASED INDICES INCREASE THE SENSITIVITY TO SMALL CHANGES IN HIGH-QUALITY STREAMS.

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The bioindication value of lotic water mites is well documented, but mite small size, complex life histories with many pre-adult stages, and difficult taxonomic identification at species level have led to mite exclusion from most biotic indices based on benthic macroinvertebrates. The Star-ICMi index, which is the official index for compliance with the EU's Water Framework Directive (WFD), also excludes water mites. We have used macroinvertebrate data from 216 stream sites in south-central Italy to assess water mite bioindication potential and the reliability of the new mite-including PTHfam index to describe stream ecological status throughout the possible range of quality classes (QCs) sensu WFD. Mite bioindication potential was highest at family level. The PTHfam index is simply the number of Plecoptera, Trichoptera, and Hydrachnidia families found at any given site. Of the other four indices used for our multiple comparison, the BMWP index also exhibited high reliability and, along with the PTHfam, the most symmetrical distribution of QCs. Number of mite families per QC was statistically fully separated only for the PTHfam index. All indices except for the BMWP and the PTHfam tended to become relatively insensitive to changes in benthic assemblages in the best QCs, suggesting a limited ability as sentinel indices at the onset of ecological deterioration. We believe that the newly proposed PTHfam index has a high potential for use in WFD-compliant bioassessments of stream ecological status due to its reliability and simple, labor-relaxed, and user-friendly formulation and associated methodology.

PHYTOPLANKTON-BACTERIA COUPLING: NEW INSIGHTS ON A RENEWED TOPIC

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The literature proposes that the existence of phytoplankton-bacteria coupling (PBC) should lead to a significant correlation between heterotrophic bacterial production (HBP) and dissolved primary production (DPP). This correlation may be stronger when the strength of PBC, defined as the extent to which DPP meets bacterial carbon demand (BCD), becomes higher.
In this work we analyze the PBC along a 4-years period (2013-2016) in La Caldera (Sierra Nevada, SW Spain), an oligotrophic high-mountain lake where allochthonous carbon input is negligible, HBP is carbon-limited and a strong PBC is expected. We followed two complementary approaches: regression analyses (HBP vs. DPP) and the variation of the BCD:DPP ratio (demand:supply ratio for carbon). In turn, BCD was estimated through determination of a conversion factor for the lake between HBP and bacterial respiration (BR), as well as an empirical model stemmed from the relation between HBP and BR for a wide set of high-mountain lakes in Sierra Nevada.
We found a high variability in the strength of PBC along the interannual scale. In 2013, HBP correlated with DPP, consistent with BCD:DPP < 1; however, in the following years these correlations were not found, regardless BCD:DPP was below 1 (2014, 2016) or above 1 (2015). These findings challenge the reliability of the BCD:DPP ratio to predict PBC. Abiotic factors related to global-change stressors, as well as biotic factors (e.g. carbon release linked to protist bacterivory) may modulate the PBC in this ecosystem.

SPATIAL AND TEMPORAL VARIABILITY OF BIOLOGICAL MONITORING INDICES IN LOTIC SYSTEMS

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The analysis of spatial and temporal variability of biotic indices is a major concern for water quality monitoring programs. The analysis of biotic indices currently used to assess the ecological status of water bodies is essential in guiding further development and refinement of assessment methods. Based on the quantitative row data (composition of benthic communities and numerical density of taxa) provided by the national monitoring system several indices were calculated using the national methods. In most cases, intra- and inter-annual fluctuations were significant suggesting difficulties in establishing the boundary between quality classes. The implications of the high variability of biotic indices on the assessment of the water quality and ecological status of lotic systems are discussed and solutions for improvement are suggested.

HYPERSPECTRAL MEASUREMENTS OF CYANOBACTERIA AND THEIR SPECIES-SPECIFIC SPECTRAL FEATURES IN DIFFERENT ENVIRONMENTAL PATTERNS

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The blooms of cyanobacteria are recognised as a serious threat to the good ecological quality of inland waters, because these events, whose frequency and intensity could be exacerbated by the climate change, can seriously compromise the use of the water resource and the ecosystem services it provides. The implementation of early warning tools, such as those available by remote sensing investigations, operating on a large scale and at high frequency, would reduce the efforts needed to face the effects of an algal bloom, minimizing the use of lengthy and expensive traditional monitoring. To reach this goal, cyanobacteria should be detectable at species level, developing algorithms dedicated to the identification and mapping of the blooms: this the main focus of the project BLASCO (Blending LAboratory and Satellite techniques for detecting CyanObacteria), started in 2015. Here we presents the results of some laboratory experiments, showing that cyanobacteria have peculiar optical properties, not only at species level, but also at strain level. Moreover, we demonstrated environmental stress (light, temperature or nutrient stress) affect the shape of the reflectance spectra. Other experiments were carried out to study the variability of the spectral signatures in pure culture of cyanobacteria vs. mixed cultures (cyano, chlorophytes and diatoms). These results will allow developing new and more reliable calibration algorithms for the interpretation of satellite images, to monitor the specific cyanobacterial blooms under different environmental situations and to identify potentially toxic species in pre-bloom conditions.

DISTRIBUTION AND GENETIC CHARACTERISTICS OF NATIVE EUROPEAN CRAYFISH SPECIES IN THE BALKAN PENINSULA

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The Balkan Peninsula, one of the most important Pleistocene glacial refugia in Europe, is characterized by a high genetic diversity for many aquatic species, including freshwater crayfish. It was observed that some populations of European crayfish exhibit higher genetic variation compared with the rest of Europe, and hence form genetically unique stocks of conservation importance on the continental scale. Nevertheless, in contrast to most European countries, the detailed information on their exact distribution in the Balkans as well as genetic characteristics is still scarce. We will summarize historic and current distribution records, and our own investigations of European crayfish occurrence in two Balkan countries, Albania and Bosnia and Herzegovina. Two European crayfish species, Astacus astacus and Austropotamobius torrentium, are considered to occur in Albanian freshwaters, however to the best of our knowledge, no studies on their distribution have been published and assumption on their presence in Albania has been mainly based on the records from the transboundary waterbodies. In Bosnia and Herzegovina, apart from A. astacus and A. torrentium, two more European crayfish species, Astacus leptodactylus and Austropotamobius pallipes, have been recorded. Although a report on their distribution has been recently published (Trožić-Borovac 2011, KMAE 401:26), our investigations provide an important update on the occurrence of A. astacus and A. pallipes in southern Bosnia and Herzegovina. Moreover, we provide information on genetic variability of A. astacus and A. pallipes populations in both countries that can be of importance for their conservation and management in the Balkan Peninsula.

CHANGES IN BIODIVERSITY RESPONSES TO MULTIPLE STRESSORS IN THREE EUROPEAN BASINS

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Rivers suffer of an important decrease in species diversity compared to other aquatic and terrestrial ecosystems due to a variety of stressors related with human activities. Species provide different roles in the functioning of the ecosystem, and their loss may reduce the response capacity of the ecosystems in front to a stressor.

We present the results of the analyses of the biodiversity patterns for bacteria, algae, macrophytes, macroinvertebrate, and fish communities of the Adige, the Sava, and the Evrotas rivers (GLOBAQUA basins), and the links of these biodiversity patterns with different environmental pressures. The data obtained from the field work during two consecutive samplings has been evaluated according to structural biological community parameters (species composition and abundance).

Overall, hydrology was the main driver determining species composition but also their abundance, richness, and diversity in the biological compartments studied, except for bacteria. Higher flows reduced invertebrate abundance and richness but favoured macrophyte and diatom richness and diversity. Flow intermittency affected negatively diatom abundance and diversity. Morphological alterations in the river basin and chemical pollution, mainly the presence of PhACs (urban pollution) and pesticides, were related with lower insect richness. Emerging compounds (PhACs) were also related with a reduction in macrophyte diversity.

These results put in evidence the impact of the combined effects of multiple stressors on biological diversity in three basins, which may serve as representatives of the real situation in European freshwater systems.

MONITORING OF PRIMARY PRODUCERS COMPOSITION, COVER AND ABUNDANCE IN MANTUA LAKES SYSTEM FROM SENTINEL-2 DATA

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Earth Observation (EO) data are a useful tool for monitoring water quality and primary producers in freshwater ecosystems. We used Sentinel-2A (S-2) images to assess phytoplankton and macrophytes composition, abundance and distribution in a shallow eutrophic fluvial lake system (Mantua Lakes, Italy). Field measurements acquired from 2014 to 2016 (14 dates, 15 sites) were used for calibration and validation of EO products. 21 S-2 images (5 synchronous to in situ data) were corrected for atmospheric effects with 6SV code. For phytoplankton biomass (chlorophyll-a) we applied a combined semi-empirical algorithms and spectral inversion techniques (bio-optical modelling) to S-2 corrected images (MAE=4.21; R2=0.92). Phytoplankton functional types dominance were detected from two S-2 images (in situ counts were available) with bio-optical modelling inversion by using specific phytoplankton absorption and back-scattering coefficients. Four macrophyte community types (helophyte, emergent, floating and submerged-floating association) were mapped using a rule-based hierarchical classifier fed with multi-temporal seasonal WAVI index (OA Kappa 87.9%; 0.85). Moreover, fractional cover and leaf area index were estimated using semi-empirical algorithms (WAVI and MCARI respectively) with a validation of MAPE<20% for both parameters. Chl-a maps showed an increase of concentrations from upstream to downstream in summer season, in particular in stagnant water due to cyanobacteria growth. Emergent and floating macrophytes were dominant in the lakes. Lower values of biophysical parameters were found in 2016 compared to 2015. All the products obtained were shared with local water management authority to improve the plan for monitoring and safety. This research is part of the EU FP7 INFORM (Grant No. 606865).

INTERLABORATORIES MACROINVERTEBRATE TAXONOMY PROFICIENCY TEST

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Laboratorios Teconologicos de Levante organizes a proficiency test (PT) with the aim to assess the performance of laboratories worldwide in the field of macroinvertebrate taxonomic determination. The PT supports the implementation of the Water Framework Directive 2000/60/EC (WFD), which aims at achieving a long-term high level protection of the aquatic environment. Our company is a pioneer in Spain; it was the first Spanish organization in achieving the accreditation of a biological quality index determination under ISO/IEC 17025. The test material consists of representative macroinvertebrate taxa individuals that typically occur in freshwaters from the Mediterranean/Central Europe regions. Participants must perform the taxonomic classification of the individuals. The taxonomic precision of each laboratory and/or technician is assessed with the percentage taxonomic disagreement (PTD) and the percentage difference in enumeration (PDE) proposed by Stribling et al. (2003). Also to know what kind of errors have occurred we assign the errors to the 3 types described by Stribling et al. (2008): Disagreements: when the laboratory and /or technician determines a taxon that is not present in the prepared sample. Hierarchical differences: when the laboratory and/or technician does not reach the family level. Missing specimens: when the laboratory and /or technician does not determine a taxon that is present in the prepared sample.

ASSESSMENT OF ECOLOGICAL INTEGRITY OF VERY LARGE RIVERS (VLR) IN FRANCE: A REVIEW OF THE CURRENT BIOLOGICAL METHODS AND PROPOSED

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The European Water Framework Directive radically changed the way Member States (MS) considered water management by placing ecosystem integrity at the base of management decisions. Since then, all MS expended considerable time and resources to collect appropriate biological, environmental and pressure data, and to develop operative tools in order to elaborate river basin management plans. A major step was achieved at the end of 2012 with the intercalibration of 230 bioassessment methods from 28 countries. Nevertheless, further effort is still required as around 100 methods (30% of the total) are not yet developed and/or intercalibrated. In particular, Very Large Rivers (VLR), despite their numerous ecological and socio-economical benefits (they are ecotones between freshwater, marine environments and floodplains, usually provide a lot of ecosystem services, and often constitute species-rich ecosystems), are still often lacking from a complete set of WFD bioassessment tools. Several reasons can explain this: VLR are very difficult to sample with accuracy and representativeness due to the size of the sampling sites, they are multi-impacted water bodies where the definition of reference conditions and ecological thresholds is often challenging, etc. Here we present an overview of the French national assessment systems for VLR, with reference to the current available methods and the methods in development, and the proposed ways to go forward in order to enhance the assessment of their biological integrity under a WFD scope, and beyond.

ECOLOGICAL INDICATORS AND MICROBIAL SOURCE TRACKING TOOLS IN HIGHLY DEGRADED ANDEAN BASINS

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We studied the upper Guayllabamba river basin, a high altitude Andean basin, in which land conversion is extensive due to urbanization, cattle raising, and agriculture. In 2004 we studied the ecological quality in 46 sampling sites in this basin using tools, developed in Spain, to determine the ecological status of rivers. We revisited all these sampling points to assess current ecological status. Moreover, this time we added viral indicators as a microbial sources tracking tool to assess the origin of microbial pollution. Our aim was to compare the ecological quality loss after 12 years and to determine the relationship of ecological indicators with viral source tracking tools. We found historical ecological changes among years in several sections of the basin. Viral indicators are spatially distributed along the basin differentiating cattle raising-sources from human wastewater discharges. Currently there is not ecological or microbial source tracking program in this basin although there is an enormous need of this information for sanitation and restoration infrastructure that is planned for these whole upper basin where more of 2 million people live.

MONITORING OF ECOLOGICAL RISKS OF RIVER CONTAMINATION FOR FISH POPULATIONS

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Water pollution is considered as one of the main contributor to fish declines observed worldwide. Therefore, assessing the impact of chemical pressures on freshwater fish species, considered among the most threatened ones in Europe by the IUCN, is of main interest to understand ecological risks of river contamination. If the European Water Framework Directive (EU-WFD) requires to implement chemical and ecological analyses to monitor surface water bodies, this should be completed by toxicity measurement at the individual scale to properly assess ecological risks of surface water contamination. In this purpose, biomarkers should be used to provide early warning signals of effects on biota exposed to environmental pollutant mixtures. This work highlights through field experiments the complementarity of biomarkers, chemical and ecological analyses to provide relevant information to understand the impacts of chemical pressures on fish population dynamics. A battery of 9 biomarkers (including pollutant metabolization, oxidative stress, genotoxicity and neurotoxicity biomarkers) was investigated in sticklebacks (Gasterosteus aculeatus) measuring physiological endpoints in fish from sites officially monitored within the EU-WFD. The relationship between biomarker responses and fish population disturbances was further explored studying fish reproduction defects due to field paternal exposure to environmental genotoxicants. Our results point out significant decrease in progeny survival of offspring stemming from fish located in contaminated sites correlated to genotoxicty biomarker responses measured in parental germ cells. Finally, chemical, biomarker and ecological indexes were calculated and integrated into a decision matrix to draw consistent standard conclusions regarding the environmental status of the studied sites.

EVALUATION OF HEAVY METALS, PESTICIDES AND EMERGENT POLLUTANTS CONTENT IN THE TULA RIVER MEXICO

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Presence of pollutants such as : heavy metals, pesticides, pharmaceuticals, personal care products (PPCPs), or halogenated organic compounds on surface waters is a major concern due to their environmental and human impact. The uncontrolled release of such contaminants and the scarce information of their content in Mexican surface waters increase the interest to determine their concentration levels in Mexican natural waters. The aim of this work is to: (1) quantify these pollutants for the first time in the water of the Tula river in Mexico, (2) use biomonitoring metrics as complementary tools for the assessment of Mexican rivers and (3) estimate the impact of industrial, agricultural and urban activities on the water quality in this watershed. To our purpose, water samples collected along the river were analyzed to quantify the presence of arsenic and six heavy metals, eighteen organochloride pesticides, eight PPCPs and fourteen major elements (e.g., nitrate). In addition thirty-five macroinvertebrates-based biomonitoring metrics were computed. We performed statistical data analysis to better understand the impact and correlation of the pollution measurements using, clustering and PCA methods with the R environment for statistical computing and visualization. Our findings from mining the data indicate that urban wastes and agricultural activities have an impact on the water quality of the Tula river. The biomonitoring metrics show to be useful complementary tools for the assessment of the river. Finally, high concentration levels of ibuprofen and naproxen were found, such findings suggest that restorative and preventive actions need to be implemented.

PESTICIDES IN SMALL WATER BODIES - IMPORTANT DRIVERS IN UNDERREPRESENTED STREAMS

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Streams in agricultural landscapes are strongly affected by environmental stressors including nutrient or pesticide input. Due to their low dilution potential, inputs into small water bodies (SWB) are comparatively more likely to impair the fauna and flora than in larger streams. Although, SWB represent a large fraction of all water bodies, they have received less consideration in water monitoring programs. Within the framework of the German national action plan (NAP) to improve the sustainable use of plant protection products we analyzed nationwide pesticide monitoring data sampled between 2005 and 2015. To specifically address agricultural SWB, we performed statistical analysis of pesticide concentrations in 1302 sampling sites and their upstream catchments (catchment size <30km^2, land use >40% agriculture). In detail, we modeled the occurrence of pesticides in dependence of catchment parameters including precipitation, geographic region, slope as well as of the cultivated crops in the respective years. Furthermore, we traced seasonal patterns of substance groups (e.g. herbicides). Our results show a relationship between pesticide findings and short-term precipitation events and compound-specific seasonal patterns. The occurrence of pesticides was further associated with a decrease in the abundance of sensitive benthic invertebrates sampled in or close to the pesticide sampling sites. We provide suggestions for future monitoring strategies and discuss the relevance of including pesticides in studies on small water bodies.

PRESENCE OF MACROPHYTES UNDER LIGNITE MINE WATERS PRESSURE

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Problems related to the impact of open pit mines on the environment are described mostly on the basis of the evaluation of changes in groundwaters, water content in surrounding soils, the shape of the cone of depression and water volume in rivers. Water quality of watercourses receiving mine waters has been studied less thoroughly and if it was analysed, only physico-chemical data were taken into account. Studies were carried out in central Poland and macrophytes were identified in 100 metres sites to evaluate the impact of mine waters on the presence of aquatic plants. Changes of species number and shifts in species composition below mine waters discharge were surveyed. Biological diversity indices (Shannon-Wiener W, Simpson D, uniformity J) were calculated to evaluate rate of observed changes. The lowest diversity of macrophytes was found in the sites below mine waters discharge points where decline of biodiversity was sometimes statistically significant. Together with biological studies most important water quality parameters like pH reaction, conductivity, soluble reactive phosphates, nitrates and total phosphorus were analysed in all selected sites. Results showed, that brown coal mine waters have different quality according to the type of drainage.

DOES THE SIDE MATTER? POTENTIAL EFFECT OF SIDE-SPECIFIC DATA PROCESSING ON THE RESULTS OF FISH MORPHOMETRIC STUDIES.

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To avoid the effect of fluctuating asimmetry morphometric measurements usually made strictly on one side of the individuals examined. However, since there is no consensus about which side should be measured, one can find studies both dealing with the data derived from the right and left side of the fish body. Moreover there is no information published how is the side-specific data processing can be affect the intercalibratability of the results of population level morphometric studies if the measurements were made using different methods. Therefore the aim of this study was to examine, the side effect in case of geometric and distance based morphometric methods using different species' datasets. For the analyses data of four common fish species (bleak, roach, perch, pumpkinseed) collected from three closely related sampling sites were used. 11 landmarks were placed and 22 distances were measured on digital images taken from both sides of all studied individuals. The datasets were analyzed using CVA and PERMANOVA. Results of geometric morphometric analyses showed significantly lower effect of the side in each species, than the population level differentiation. Distance based (classic) analyses showed similar results, however in this case the population level differences were lower and the side effect was more considerable in each species. Our results indicated, that during population level morphometric studies the effect of body side could be neglected if geometric morphometric method is used, however it should be taken into consideration in case of distance based methods.

DIATOM-BASED ECOLOGICAL ASSESSMENT ON THE RIVERS OF THE TROPICAL ISLAND, MAYOTTE (FRANCE) USING DIFFERENT APPROACHES

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Diatom-based indices are widely used in the Water Framework Directive (WFD - European Commission, 2000) for ecological quality assessment of water bodies in Europe. The majority of these indices are based on a simple formula (Zelinka and Marvan, 1961) that, beside the abundance, uses the optimum and tolerance values of the species along an environmental gradient. These indices carry uncertainties in several aspects: unstable profile of rare species, possible misidentifications, incoherence in long-term datasets due to the fast-changing taxonomy, differences in ecoregions, etc. We developed and tested indices based on different approaches: a classical species-based index, a trait-based index and a molecular-based index, for ecological assessment of rivers in Mayotte island. The 75% of our data was used for the index development, and in each case, we got significant correlation with the environmental gradient of the test database (25%). The advantage of the trait-based index is that all species can be attributed to a trait, thus we keep the information of those rare species that are eliminated in the species-based one. We also avoid problematics related to misidentifications, new species, etc. The molecular-based index was developed based on molecular operational taxonomic units (MOTU) that group DNA sequences related to each other with a given genetic similarity (e.g. 95%), with no reference to taxonomy. In our presentation, we discuss these innovative tools and propose several perspectives regarding their use in biomonitoring.

INVESTIGATING THE INFLUENCE OF MULTIPLE PRESSURES ON BIOMONITORING TOOLS

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Freshwater ecosystems are among the most impacted ecosystems globally. In order to conserve and restore these environments, monitoring agencies need to be able to identify degraded rivers and streams, and diagnose the causes of degradation. Biomonitoring, defined as ‚the use of biota to gauge and track changes in the environment', is one approach that is widely used throughout Europe, including for water management and legislative purposes, driving decisions on remediation methods. Despite the implications of an incorrect diagnosis, many biomonitoring tools lack thorough validation using independent data from sites that (i) cover the full range of environmental characteristics of the rivers and streams to which they will be applied, (ii) are subject to the full gradient of the pressure(s) of concern, and iii) are impacted by multiple pressures, reflecting a realistic assessment of the performance of the tool. We provide examples of a range of approaches for testing biomonitoring tools using long term monitoring data, investigating the influence of confounding factors and the presence of multiple anthropogenically derived pressures. This analysis includes the use of a novel method of interrupted time series analysis to determine the influence of invasions of non-native species on biomonitoring tool outputs. The various approaches are applied to the testing of a sediment-specific biotic index (the Empirically-weighted Proportion of Sediment-sensitive Invertebrates; E-PSI), highlighting the potential for opportunistic data analysis to enable ecologically relevant and hypothesis driven testing, over large spatial and temporal scales.

CONTINUOUS NITRATE MONITORING OF AGRICULTURAL CATCHMENT WITH OPTICAL SENSOR

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The increased need to manage reactive nitrogen (Nr)load from agricultural lands has been widely recognized. Continuous monitoring of nitrate is important if we are to estimate nitrate load more accurately. Especially in lotic systems, where temporal variation in water quality can be rapid and significant, nutrient load estimations based on traditional, sporadic sampling can result in under- or overestimations. Thus, high-frequency measurements are needed if we want to better understand the relationships between land use, weather and water quality in streams. In this case study, we demonstrate the dynamic character of nitrate concentration in a small stream, collecting waters from a catchment located in Southern Finland. The stream Koiransuolenoja has an agriculturally influenced catchment with 23 % of arable land. Nearly half of the catchment´s soil is easily subjected to erosion, being silt and fine sand. The average nitrate concentration in the stream varies between 2.3 and 2.9 mg NOx-N l-1 (2013-2016), depending on weather conditions. Nitrate, turbidity and dissolved organic carbon concentration in the stream water were monitored continuously by a UV/Vis s::can optical sensor using conventional laboratory results as a reference. As organic carbon can interfere with nitrate results obtained by an optical sensor, a suitable calibration method is important to get reliable data. Also, the differences in nitrate load obtained by continuous monitoring and sporadic sampling along with temporal variation will be discussed.

STABLE ISOTOPE RATIOS IN ARCHIVED FISH SCALES TRACK HISTORICAL CHANGES IN AQUATIC PRODUCTIVITY: THE STORY OF THE ŘÍMOV RESERVOIR

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A unique collection of archived fish scales was analysed for stable isotopes to infer historical changes in nutrient loading and primary productivity of a lacustrine ecosystem – the Římov Reservoir, South Bohemia. Scale samples and other environmental variables (total phosphorus, dissolved organic carbon, chlorophyll-a, fish biomass) have been collected from 1979, when the reservoir was filled, onwards. High external inputs of anthropogenic nutrients caused that the reservoir was very productive during the 1980s. Since the 1990s, reservoir primary productivity has declined, apparently due to the decreasing inputs of anthropogenic nutrients and concurrently increasing input of humic substances released from the catchment. Total fish biomass has steadily declined over the same period. Fish scale δ13C and δ15N increased significantly within a few years after the reservoir was filled, probably in an attempt to reach isotopic equilibrium with the newly created environment. Afterwards, however, fish scale δ13C showed declining trend and we argue that this reflected the decreasing primary production of phytoplankton. Our results suggest that isotopic composition of fish scales can serve as a useful tool for monitoring long-term variation in aquatic productivity. Archived scale collections thus represent an extremely valuable resource for retrospective analyses addressing ecological change issues.

PROXIMAL SPECTROMETRY FOR MONITORING WATER QUALITY PARAMETERS

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In most river systems, water quality parameters such as suspended particulate matter concentrations are considerably fluctuating within the course of a year. While precise estimates of concentrations and mass fluxes are needed by water managers, calendar sampling and laboratory analyses cannot comply with these often highly dynamic discharge and transport regimes. Therefore, we apply a customized, bridge-mounted, above-surface miniature spectrometer (Ocean Optics) system to autonomously record Vis-NIR remote sensing reflectance of a river's surface layer. The spectral curves are related to simultaneously measured water quality parameters by partial least squares regression. After calibration and validation, reflectance measurements can be used to estimate concentrations for short time steps during daylight hours. Due to its ecological relevance and proxy capabilities, preliminary mesocosm reflectance experiments with were made with suspended matter, the most common pollutant in river systems. Partial least squares models built from these data show reasonable predictive power for a wide range of concentrations. Having great numbers of narrow bands, the spectrometer allows the distinction of targets with similar spectral signatures such as waters with similar concentrations of different constituents. Hence, the extraction of additional optically active and inactive water quality parameters such as chlorophyll and total phosphorous concentrations and electrical conductivity will be further tested using empirical and analytical approaches.

EDNA DESCRIBES LONG-TERM COMMUNITY CHANGE UNDER HUMAN PRESSURE

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Long community time series are exceedingly rare, but they are necessary to evaluate the results of natural experiments on ecosystems. These experiments were frequent during the last century as humans modified the composition and functioning of most communities on Earth. We used sediment-preserved DNA to evaluate how lake eukaryotes react to decade-long chemical and thermal pollution, and whether their communities recover when impacts cease. Communities clearly followed changes in stressors. Decrease in chemical pollution is accompanied with successional patterns, while periods of thermal stress cause abrupt shifts in community composition. The results emphasize the potentials of eDNA to link community ecology and paleoecology through taxonomically comprehensive time series of community composition.

HOW MUCH CAN ENVIRONMENTAL DNA (EDNA) REFLECT A LOCAL MACROINVERTEBRATE COMMUNITY IN A LOTIC SYSTEM?

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Recent developments in the use of molecular techniques for bio-assessment has led to a revolution in the way we can monitor aquatic systems. Current methods of monitoring macroinvertebrates in freshwater rely heavily on the capture or sighting of the target species, followed by correct taxonomic identification, which is not always possible. This is particularly true when referring to invasive alien species (IAS) which can be cryptic, in low density or in juvenile stages. This makes eDNA a particularly interesting complimentary tool when assessing macroinvertebrate communities and as an early warning system for new IAS. However, little is known about how molecular methods compare to established methods in lotic systems. Here we demonstrate the findings of a series of field experiments comparing established sampling techniques (kick samples) with molecular samples, namely - DNA "smoothies", eDNA water and eDNA sediment samples.

DIVERSITY OF SOUTH AMERICAN RIFFLE BEETLES (COLEOPTERA: ELMIDAE) EXPLORED USING DNA BARCODES

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South America, and mostly its tropical Amazonia, is with no doubt an area with extraordinary high level of biodiversity. Beside the fact that its biota is the object of interest for biologists from around the World already for a long time, new species are still beeing discovered every day. The same situation is in the family Elmidae, a group of small beetles inhabiting various lotic habitats. Since the elmids are strictly aquatic and long-lived, spending (with few exceptions) whole life submerged, they form an important component of benthic macroinvertebrate communities, and can serve as good indicators of long-term ecological changes. Unfortunately, if compared with e.g. mayflies or caddisflies, little attention is paid to this group of aquatic insects. At present, slightly more than 1.500 species are known in the family, from which around one third inhabits streams and rivers in South America. Until recently, all descriptions of the new taxa (species, genera) were based exclusively on morphological characters. During our biodiversity research project (2011-2014), we have sampled small areas (in respect to the whole Amazonia) in Venezuela and Ecuador, and collected fresh and ample material, which is now being processed. But, it is for the first time for South American elmid fauna, that except morphology, also DNA barcodes are employed. Even our research is at the beginning, the first data gained reveal distinct advancement in describing the real diversity of the studied family.

In this work we analysed samples from several selected genera from both subfamilies, Larainae and Elminae, and here we present examples of how molecular data improved our knowledge on the taxonomy of Elmidae of South America. In the genus Onychelmis Hinton, 1941, which included 3 morphologically extremely similar known species we identified 5 new species; in the genus Notelmis Hinton, 1941, which had 2 known species, we identified 4 new species; in Neblinagena Spangler, 1985 we identified 2 new species. Beside discovery of the new species, the DNA barcodes allowed us to suggest paraphyly of several genera (Neoelmis Musgrave, 1935, Gyrelmis Hinton, 1940, Neblinagena Spangler, 1985, Xenelmis Hinton, 1936).

This work is very far from being finished, but we already showed very clearly, that the diversity of riffle beetles in South America is manyfold higher than thought and that we have a huge gap in its understanding. However, we also proved DNA barcodes invaluable tool that can reasonably help to fill it.

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RS10 – Poster

SEDIMENTARY ANCIENT DNA OF AQUATIC PLANTS AND DIATOMS TO TRACK HOLOCENE ENVIRONMENTAL CHANGES IN SIBERIAN ARCTIC LAKES

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The prospected strong high-latitude warming is projected to cause a northward move of the arctic-boreal treeline, potentially having a strong impact on both terrestrial ecosystems, and, through changes in the water chemistry, on the many lakes of the region. The treeline has experienced pronounced fluctuations throughout the Holocene, and analyses of lake sediment records can elucidate the timing and mode of past changes. In recent years, ancient DNA from lake sediment cores has proven to be a highly efficient tool to reconstruct past ecosystems. Analyses of environmental changes using plant DNA from lake sediment cores have mostly focused on the terrestrial surroundings of the lake. As the DNA record in sediments is mostly of very local origin, metabarcoding assays targeting vascular plants also yield aquatic taxa. They are excluded in analyses of terrestrial vegetation, but they potentially offer valuable paleolimnological and hydrological information, for example as proxies for water level variations. Further aquatic taxa, like diatoms, are recognized as suitable proxies for reconstructions of physical and chemical changes of lake water. Here, we use DNA metabarcoding to analyse and compare these two aquatic proxies to reconstruct Holocene environmental changes in lakes from in the treeline area. We find simultaneous changes in aquatic plant and diatom communities, which support changes in lake level in accordance with climatic fluctuations.

TRACKING PHYSIOLOGICAL STATUS OF AQUATIC ORGANISMS IN VIVO BY MICROENCAPSULATED BIOMARKERS BASED ON FLUORESCENT MOLECULAR PROBES

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Modern techniques for exploring internal physiological parameters of small organisms are usually accompanied by destruction or severe damage of the organism after tissue sampling. At the same time, there is a wide range of fluorescent molecular probes which are sensitive to specific physiological parameters and can be used as local optical sensors inside the organism. Immobilization of the probes into semipermeable microcapsules offers the promising possibility to both combine different molecular probes in the same microcapsule and minimize influence of the sensors on the organism. In this study we demonstrate applicability of encapsulated fluorescent probes (so-called microencapsulated biomarkers) for monitoring of physiological pH in crustaceans and fishes under different stress conditions. Microencapsulated biomarkers, being injected in circulatory system of amphipods Eulimnogammarus verrucosus endemic to Lake Baikal, showed decrease in median hemolymph pH from 8.2 to 7.6 both under hypercapnic conditions and exposure without aeration. pH changes correlated with increase of lactate content in amphipods under the stress exposures. On example of adult Danio rerio, microencapsulated biomarkers were introduced into capillaries of gills and muscles of fishes and used for parallel pH monitoring in bloodstream and interstitial fluid of muscles. Coma-induced hypoxia led to acidification of blood from median pH 7.4 to approximately 7.1. pH in muscles right after injection of microencapsulated biomarkers was significantly acidic (6.9) and rose to blood level in normal conditions during the observation, while hypoxia prevented pH restoration. This work was supported by Russian Science Foundation (#15-14-10008) and Russian Foundation for Basic Research (#15-29-01003).

DISTRIBUTION AND ECOLOGY OF RARE BACTERIAL PHYLUM GEMMATIMONADETES IN AQUATIC ENVIRONMENTS

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Aquatic environments are populated by diverse microbial populations. Apart from several dominant and intensively studied groups, a bounty of minor species exists whose physiology and environmental role is largely unknown. The bacterial phylum Gemmatimonadetes was established in 2003, and to date contains only four cultured species. In 2014 we isolated a new semiaerobic strain from a freshwater lake in the Gobi Desert, which contained fully functional bacterial photosynthetic reaction centers. This organism, named Gemmatimonas phototrophica, represents a completely new group of phototrophic organisms and it is also the only cultured phototrophic member of the phylum [1,2].
To learn more about the environmental distribution of Gemmatimonadetes we analysed 1706 publically available metagenomes. The 16S rRNA reads signalizing the presence of Gemmatimonadetes were found in various freshwater environments, including sediments, where they typically represented 0.1-1% of total 16S rRNA reads. They were also present in agricultural and arctic soils, permafrost, biofilms and plant surfaces. However, Gemmatimonadetes were not common in marine environments, except estuaries. The metagenomes were further searched for the acsF gene, serving as a marker of phototrophic species. Here phototrophic Gemmatimonadetes represented 1-10% of total reads in wasterwater plants, lakes, rivers and soils. Based on the obtained data it seems that Gemmatimonadetes prefer a particle attached life-style in aerobic to semiaerobic environments where they utilize available organic matter [3].

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A PRELIMINARY ASSESSMENT OF THE FRESHWATER DIVERSITY OF COLEOPTERA IN GREEK ISLANDS.

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Coleoptera are the most diverse order of living organisms possessing a variety of morphological and ecological attributes. Little is known about the diversity of freshwater Coleoptera distributed in Greece and there is yet no comprehensive research on these insects neither from the mainland nor from the islands. In the present study, specimens were collected from three Greek islands located in the Central and South Aegean Sea. Fifteen, sixteen and eighteen freshwater systems, including springs, brooks, streams, lakes and estuaries were surveyed from Andros, Euboea and Crete, respectively. So far, species belonging to four families have been recognized morphologically. DNA barcoding has proved to be a trustworthy tool for clarifying the taxonomy and assessing the phylogenetic relationships of invertebrates' species. Hence, based on COX1 mtDNA, we also assessed the beetles' insular diversity in a reliable and effective way for the first time in Greece.

A ZOOPLANKTON'S GUIDE TO THE KETTLE HOLE

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The Baas-Becking's hypothesis (1934), known as 'everything is everywhere' (EiE), embraced the view that microscopic organisms are globally distributed due to high dispersal potential. The theory has been under discussion for quite a long time. Molecular approaches have changed our understanding of the term 'species' and provided valuable information about clonal diversity, coexistence, and biogeographical patterns. Kettle holes are underrated biodiversity hotspots. Their changing hydroperiod, size, and nutrient concentration allow for existence of various communities, not found anywhere else. We chose 20 kettle holes in the Quillow catchment region (Land Brandenburg, Germany) to investigate the dispersal patterns and populations' structure in this agricultural area. Our main focus is on the Brachionidae family, in which cryptic species complexes are widely known.

Keywords: passive dispersal, microsatellites, kettle holes, cryptic species complex

MULTIPLE-STRESSOR EFFECTS ON STREAM INVERTEBRATES: METABARCODING REVEALS CONTRASTING RESPONSES OF INVERTEBRATE COMMUNITIES

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Multiple anthropogenic stressors impact freshwater ecosystems worldwide. Current biodiversity assessment programs mostly monitor these impacts by analyzing ecological traits assigned to invertebrate taxa. For practical reasons, higher-level taxonomic groups (genus or family) are often used in these assessments. However, this approach has been shown to potentially bias assessments as even closely related species can differ substantially in their biological traits, thus emphasizing the need for species-level data. DNA metabarcoding is a powerful tool that reliably generates MOTU (Molecular operational taxonomic unit)-level data for whole communities by sequencing a standard barcoding gene, such as the mitochondrial COI gene fragment in animals. This allows investigating responses to environmental stressors on community level. Here, we sampled 31 stream sites in southern New Zealand covering a gradient of agricultural stressors (fine sediment, nutrient levels, catchment land use). We amplified a 420 bp region of the COI gene for two replicates of each sample and sequenced a total of 36 millions reads. 1062 MOTUs were identified, of which 455 were assigned to metazoans. Test for differences in community composition showed a clear separation of communities depending on catchment land use and concomitant nutrient levels. A high individuality of communities was found, which allowed to "fingerprint" streams. While both complete and metazoan communities were distinct between streams in different land use intensities, this was most obvious for the complete community. Our results highlight the considerable potential of DNA metabarcoding and the potential of including non-metazoan taxa into freshwater ecosystem assessments.

DNA-METABARCODING REVEALS LINKS BETWEEN COMMUNITY STRUCTURE AND ECOSYSTEM FUNCTION

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One of the potential benefits of using molecular approaches in freshwater ecology is an increased understanding of the relationship between microbial community structure and ecosystem function. We have developed a DNA-metabarcoding approach for the study of all three domains of life in lake water and sediments. Simultaneous study of archaea, eukaryotes, and prokaryotes has begun to provide some insights into how the microbial community can be linked to independent measures of ecosystem function. Specifically, we present examples of recent research into zoo-, phyto-, and bacterioplankton communities in lakes and how these are related to ecosystem carbon flux. Our work has revealed a number of surprises (both pleasant and unpleasant) and it is clear that the ability of molecular data to yield quantitative measures of species (or OTU) abundance remains one of the key potential benefits of molecular research in freshwater ecology.

TROUBLESHOOTING IN QPCR FROM ENVIRONMENTAL SAMPLES: MCYE GENE QUANTIFICATION OF GENOMIC DNA FROM DANUBE DELTA SHALLOW LAKES

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This study aims to expose, explain and justify different ways of analyzing the raw data obtaining by qPCR using original samples: environmental DNA from Danube Delta shallow lakes. In this way, real data will clear exemplify the difference between automatics versus manually settings of the qPCR machine software used in order to correct the primary data of this kind and to obtain robust results. All the decision taken for any modification on the raw data are explain in details by showing tables and figures with the original data. Because most of the papers do not give such details in their dedicated section and because scientists do not comment the difficulties after they manage or not to solve them, unfortunately, we are deal with a lack of studies dedicated on this section of qPCR namely absolute quantification of any gene from eDNA using TagMan assay as far we could conclude. All the guides, tutorials and general rules published, shared and recognized, as well examples from others studies were used as reference or tested for comparison in this study. The importance of this synthesis consist mainly in this type of exposure of any technique troubleshooting, especially in molecular investigations that will help specialists either to correct some choices, to generate new questions or ideally, to propose better solutions.
This work was supported by the Swiss Enlargement Contribution, project IZERZ0 – 142165, "CyanoArchive", in the framework of the Romanian-Swiss Research Programme. Raw data were generated in the Genetic Diversity Centre of ETH Zurich.
Keywords: absolute quantification, cyanobacteria, Danube Delta, mcyE gene, qPCR troubleshooting, replicates, standard curve, TaqMan

A NEW SPECIES OF AUSTROTHELPHUSA (CRUSTACEA: BRACHYURA: PARATHELPHUSIDAE) FROM THE GILBERT RIVER, NORTH QUEENSLAND, AUSTRALIA

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A new species of Austrothelphusa, A. gilberti, is described from the westward flowing Gilbert River Catchment, in northern Queensland. Genetic sequences for (COI) and (16s) place it closest to Austrothelphusa wasselli Bishop, 1963, described from the Stewart Drainage Basin, north-eastern Queensland. It differs from A. wasselli by several small but significant morphological characters. It also shows CO1 and 16s divergence which confirms its novel specific status.

EVOLUTIONARY ADAPTIVE RESPONSES TO RAPID CLIMATE CHANGE IN TWO DIFFERENT STRAINS OF BRACHIONUS CALYCIFLORUS SPECIES

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Temperature is a key environmental factor affecting many life history traits. Aquatic organisms can tolerate environmental variation by averting fitness declines via “phenotypic plasticity”, “dispersal” or “genetic adaptation”. Recent genetic and genomic applications assess the adaptive genes involved in responding to environmental changes. We chose as our model organism the freshwater, Monogonont species Brachionus calyciflorus Pallas, 1766 because of its eco-evolutionary potentials. The aims of the present study are to (i) characterize the transcriptomes of two different strains of the species Brachionus calyciflorus, by checking for differences in functional category composition under two different temperature treatments, (ii) identify candidate loci co-segregating with temperature variation and, (iii) develop markers to analyze population structure along a north to south European gradient. Two geographically isolated strains acclimatized on 20 oC selected and cultured for at least 10 generations at 14 oC and 27 oC. High quality RNA was yield by pooling 2000-4000 individuals. So far, six cDNA strand-specific libraries are prepared (one library per strain and temperature treatment, 14 oC, 20 oC 27 oC) and paired-end sequenced using one lane of an Ilumina NextSec 500 sequencing system. In parallel, we test for plasticity responses by measuring the upper lethal limits (LT50) in all the three treatments. We perform also life-table experiments to estimate phenotypic and life-history traits. By this approach, we evaluate the hypothesis of a correlation between levels of gene expression at specific candidate genes under the different treatments and the estimated phenotypic traits under the same conditions.

THROUGHOUT INSIGHT INTO BACTERIAL GROWTH RATES: GETTING HIGH RESOLUTION DATA

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Aquatic bacteria play a key role in biogeochemical cycles and food webs. Contribution of specific bacteria to ecosystem metabolism depends on their abundance and growth rates. Growth rates of bacteria can be determined in grazer-free experiments from counts, and by using fluorescence in situ hybridization (FISH) for individual groups. However, these methods allow us to focus on few phylotypes. Here, we estimated growth rates of over 300 bacteria in food web manipulation experiments performed in September 2015 and April 2016 in the Římov reservoir. We combined high throughput sequencing (HTS, Illumina) using an internal standard to account for biases connected with DNA extraction, PCR amplification and 16S sequencing. We found that within groups known to grow fast upon grazer removal, specific phylotypes actually responded only moderately. For instance, the growth rate of Limnohabitans estimated by FISH was 1.9±0.4 per day in the grazer free treatment in the September experiment, but HTS data showed it consisted of 3 phylotypes growing at rates from 0.5±0.2 to 2.6±0.4 per day. In contrast, within groups known not to grow upon grazer removal, some phylotypes grew very rapidly. For example, all Actinobacteria grew at rates 0.9±0.2 per day, but they consisted of 33 phylotypes growing at rates from -1.7±0.4 to 2.1±0.3 per day. Our approach provided first high-resolution estimates of growth rates of hundreds of bacterial phylotypes. Its application should enhance the understanding of microbial ecophysiology, processes and food webs in aquatic environments.

ECOMETABOLOMICS: TRACING BIOCHEMICAL RESPONSES OF PERIPHYTON TO ENVIRONMENTAL STRESS

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Ecometabolomics recently emerged to a promising approach for tracing changes in the biochemical status of ecological systems, e.g. aquatic microbial communities. Metabolomics aims to provide an untargeted snapshot of all accessible metabolites, present in a biological sample and involved in primary metabolism like growth and maintenance. However, to give metabolic profiles an ecological meaning, they need to be anchored to phenotypic responses. Aims of this study was (i) to illustrate the applicability of ecometabolomics to periphyton (ii) to improve our mechanistic understanding of interacting stress responses (iii) and to outline strategies for an 'ecological anchoring' of multivariate metabolomics data. We exposed periphyton, grown in mesocosms, to high ionic loads and a toxicant individually and in combination. The concept of stress-induced community tolerance (SICT) was applied to quantify (co-) tolerance to the stressors. Diatom species composition was analysed to trace species shifts in community structure. Metabolic profiles were derived by shock-freezing periphyton and analyzing the polar and apolar phase by GC-MS after liquid-liquid extraction. The SICT-approach revealed induced tolerance towards the individual stressors and a positive co-tolerance towards the toxic stressor. Multivariate analysis of diatom species as well as the metabolic patterns revealed a clear separation of communities differing in their exposure scenarios. Metabolic profiles were integrated to the MELI (metabolic effect-level index) and showed stress- and time-dependent correlations to SICT indicating the relevance of metabolic shifts for induced tolerance. Responsive metabolites were identified and related to biochemical pathways to provide a mechanistic understanding of community tolerance towards combined stress.

DISTRIBUTION OF CRYPTIC SPECIES AS A SPECIFIC RESPONSE TO ENVIRONMENTAL EFFECTS AT LARGE SCALE: THE FRESHWATER SHRIMP CARIDINA INDISTINCT CALMAN, 1926 IN THE SOUTHEAST QUEENSLAND.

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Recent research suggests that morphologically cryptic species may differ notably in their ecological requirements and their tolerance to environmental conditions. However, it is still unclear what effect environmental stress has on the relative abundance of cryptic species, and whether the broad differences among cryptic species in their distribution reflect differences in their tolerances to various environmental variables, specifically water quality requirements. There is many genetic studies showing that many of freshwater species are harboring a number of cryptic species, which may occasionally occur in sympatry. In this study, we focused specifically on freshwater shrimp belonging to the Caridina indistincta complex in southeast Qld. Two hypotheses have been suggested in this study 1) as the taxa have different distributions, their tolerance to water quality and elevation parameters also differ, 2) as the different cryptic species of Caridina indistincta rarely exist sympatrically, their responses to environmental variables and preference to the specific habitats will differ between species. Molecular work has been conducted for147 shrimp specimens from 47 sites in 15 Catchments across southeast Qld, by sequencing a fragment of the mitochondrial cytochrome c oxidase subunit I gene (COI). The molecular approach identified three cryptic species of Caridina indistincta (Sp. A, B & D) and showed that these cryptic species seldom exist together, with only three sites containing more than one species. Based on a multivariate analysis of water quality variables at each site, Sp. A could be differentiated from Sp. B and Sp. D, but Sp. B and Sp. D overlapped substantially.

PILOT STUDY ON MACROPHYTE ECOLOGY IN CZECH RESERVOIRS AND POST-MINING LAKES

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Aquatic macrophytes belong to the most underexplored ecosystem component of freshwater reservoirs. Compared to the rest of Europe, natural lakes are rare in the Czech Republic. Instead, hundreds of man-made reservoirs and several post-mining lakes are scattered across the country. These heavily modified and artificial water bodies are of special interest, as they provide various ecosystem services such as the supply of drinking water, agricultural irrigation, industrial and cooling water supplies, power generation, flood control and recreation. While post-mining lakes share many features with natural lakes, reservoirs differ from them in several important aspects. They were mostly constructed by damming a river valley, therefore they have elongated morphology in many cases, shorter water residence time, pronounced water level fluctuations and irregular withdrawal of water, often from various strata. All these complex hydrodynamic characteristics affect aquatic biota. The pilot survey of aquatic macrophytes was undertaken in two reservoirs and two post-mining lakes. The suitability of both phytocoenological and belt transect approaches were tested for the assessment of macrophyte diversity, abundance and distribution. Based on wading, diving, hydroacoustic sonar signals and using two- and three-dimensional abundance scales, the optimal sampling approaches were defined for large-scale monitoring of aquatic plants in order to meet requirements of both science and routine practice.

PILOT STUDY ON MACROPHYTE ECOLOGY IN CZECH RESERVOIRS AND POST-MINING LAKES

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THE IMPACT OF DROUGHT UPON RESERVOIR PHYTOPLANKTON BLOOMS

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For reservoirs in the 21st century, much focus is given to their role in maintaining water quantity. However, little attention is given to the quality of their water and in particular the presence of harmful phytoplankton blooms. This presentation presents a series of investigations into this issue by applying a phytoplankton model (PROTECH) to the simulation of a reservoir in the Thames river catchment, UK. We show through successive model scenarios under what conditions blooms intensify, with particular focus on periods of drought. We focus on both past events and forecast future impacts, demonstration that whilst water quality might be maintained, often its quality deteriorates particularly when the reservoir is used to such an extent to cause its water level to decrease.

DIURNAL DYNAMICS OF CYANOPHAGES FROM MYOVIRIDAE FAMILY

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Cyanophages (viruses specific for cyanobacteria) are important biotic factor which regulate ecology, biodiversity, evolution and other life aspects of their host in salt- and freshwater. It should be highlighted that since the 80s of the twentieth century the studies have mainly focused on salt water cyanophages. Only within the last decade the researches about freshwater phages had been developed. However the ecology dependence between mentioned viruses and their host has not been fully elucidated.
In previous studies, we analyzed the dynamics of occurrence of cyanophages and their cyanobacterial host in the spring - autumn seasons fall over several years in the Polish damn reservoir - Jeziorsko. Viruses appeared together with the water bloom of cyanobacteria and coexisted till the end of analyzed period, showing a significant relationship to their hosts.
Consequently, the purpose of this study was to examine the presence of the Myoviridae family based on g91 gene and their cyanobactrial host from Microcystis genus based on 16S rRNA gene throughout the day and night period of 2 summer days in reservoir mentioned. Result indicated that cynaophages were multitudinously presented during day/night cycle. However, based on cDNA material, it was shown that that replication of virus particles has been the most intensive during afternoon hours. The influence of different environmental factors on this phenomenon should be discussed.

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VARIATION OF THE PLANKTON COMMUNITIES INDUCED BY THE HYDROPOWER DAM: A CASE STUDY IN THE MACTAQUAC RESERVOIR, NEW BRUNSWICK, CANADA

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The Mactaquac Hydroelectric Generating Station and its ~100km long reservoir (MR) were created 50 years ago. A three-year plankton investigation in the Mactaquac Aquatic Ecosystem Study was conducted in reservoir and downstream Saint John River (RIV), revealing about 341 phytoplankton and 60 zooplankton species. Generally, the species number and abundance of the plankton in the MR are higher than those in RIV but the H' index. Prior to reservoir stratification, no significant difference was found in the taxa richness or abundance ($p>0.05$) in either the MR or RIV habitats. After stratification, there was no significant variation of the phytoplankton communities in terms of the taxa richness and number of cells ($p>0.05$). The non-significant results of the ANOVAs and ANOSIMs ($p>0.05$) support the hypothesis that the downstream plankton communities are mostly supplemented by those from the reservoir. However, we found a different plankton assemblage in the downstream river most probably resulting from the in-river processes and tributary inputs ($p<0.05$). Based on DCA and RDA analysis, there was a significant importance of temperature, conductivity, dissolved oxygen, ammonia, total dissolved phosphorus, and total dissolved nitrogen for the phytoplankton pattern ($p<0.05$). The zooplankton assemblage had a strong association with temperature, conductivity, and pH ($p<0.05$). The analyses of temporal variation may reveal additional insights about the ecological relationships of the plankton communities in the research area.

VERTICAL DYNAMICS OF A LARGE RESERVOIR (ALQUEVA, SOUTHERN PORTUGAL)

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An integrated field campaign took place in Alqueva reservoir (Southern Portugal) from June to September 2014 with the objective of the determination of the trophic status and the analysis of the physico-chemical and biological vertical dynamics. Vertical profiles of environmental parameters, water samples for physical-chemical analyses and biological elements were monthly collected from three fixed platforms in the lacustrine zone and selected sites in the margins. Diatoms were collected from artificial substrates at discrete depths and from the margins and phytoplankton was analysed at discrete depths and from integrated samples. Preliminary results reveal that the trophic status of the lacustrine area and corresponding margins can be classified as mesotrophic, based in the vertical profiles (showing also the stratification) and in the TN:TP ratio. Diatom communities and indices did not differ between platforms, revealing the uniformity of the reservoir, in spite of its size. However, diatom taxa richness (S) and Shannon index of diversity (H') differed with depth, with higher values at 20m depth, which is near the bottom in two sites, and clearly below the euphotic zone. A total of 62 taxa were identified in the integrated phytoplankton samples, with chlorophytes being the taxa richest group whilst cyanobacteria dominated in abundance. The observation of the phytoplankton samples collected at discrete depths revealed the presence of cyanobacteria in the bottom samples (20m and 50m). The presence of diatoms and cyanobacteria at depths far below the euphotic zone, raises the question of which environmental parameters were influencing algal development in the reservoir.

LIMITED CONTRIBUTION OF THE DEEPEST ZONES OF A NEO-TROPICAL RESERVOIR (NAM THEUN2 LAOS) REGARDING THE FISHERIES

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As the largest Lao hydropower reservoir (Nam Theun2 - 489 km^2) plays an important role for fish production for local population, the knowledge of fish spatial dynamics and fish stock assessment are necessary to ensure sustainable fisheries. Data from fish landing survey and gillnetting monitoring were completed by day and night hydroacoustic surveys, carried out in 2015 and 2016 at the end of the warm-wet season (November) in this neo-reservoir (impounded in 2008). Vertical and horizontal beaming in the deepest zones (bottom greater than 5 m) were performed to sample the whole water column. The reservoir was sub-divided in several areas and water layers for statistical analysis. Fish densities decreased between upstream and downstream part of the reservoir, and between surface water layer and deeper ones. No significant difference of fish size was identified. The results from the two surveys done during two different hydrological situations (mixed water column versus stratification) showed similar results with very low biomass in deepest zones. Results suggest that the deepest zones of this reservoir are colonized by only few fish species, originated from the Nam Theun River, dominated by small species and individuals (mainly < 10 cm). According to the estimated annual fish landed biomass (around 1,000 tons), the deepest zones appears to have a limited role for fish population in this reservoir. This study highlights the importance of combining methods covering different spatial scales for a better approach of sustainable fisheries for reservoir.

LITTORAL MACROINVERTEBRATE COMMUNITIES IN RESERVOIRS OF THE DINARIC KARST OF CROATIA

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Reservoirs are man-made water-bodies predominantly created by using a dam or a lock to store water that may be used for irrigation, flood control or production of electric energy. Reservoirs could provide important habitats for birds, fish and other aquatic organisms. Macroinvertebrate communities were studied at nine reservoirs located in the Dinaric ecoregion of Croatia during July and September 2016. At each reservoir, one study site, with the lowest anthropogenic influence was selected. The littoral zone was sampled, on a surface area of 250 m2 or less, depending on the incline of the bank. At each sampling site, four levels of depth were defined in 25 cm segments to 1 m total depth (0 to 0.25 m, 0.25 m to 0.5 m, 0.5 m to 0.75 m and 0.75 m to 1 m). Ten samples were collected at each site using benthos hand net (25 cm × 25 cm; 500 μm). Physico-chemical water properties were measured: dissolved oxygen concentration, oxygen saturation, electrical conductivity, pH and alkalinity. Significantly higher population densities of Oligochaeta ($p < 0.05$), found in deeper littoral reaches of all reservoirs, were most probably related to substrate characteristics and their tolerance in terms of oxygen demands. On the contrary, Odonata and Ephemeroptera were significantly more abundant ($p < 0.05$) in shallower littoral parts of the reservoirs, due to higher variability of microhabitats and higher demands for oxygen concentrations. Results of this study provide new information about the ecology of benthic macroinvertebrates in reservoirs of the Dinaric karst.

FISHPONDS AS HMWB - HOW TO EVALUATE THEIR ECOLOGICAL POTENTIAL?

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Fishponds are very specific water bodies that cannot be assessed after WFD methods that are now for our disposal. The authors offered to search new more complex approach able to assess also wider relationships in landscape/watershed. This discussions will be very fecund also for a proces of seeking generally accepted approach to fishponds by various prefessional grroups.

POTENTIAL EFFECT OF FISH POND EFFLUENTS ON THE WATER QUALITY OF RECIPIENT WATERCOURSE: CASE STUDY IN THE BALATON-CATCHMENT

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Common carp is considered to be one of the most important species of European aquaculture, however the ecological impacts of the related semi-extensive culturing-technique is less known. High number of carp producing ponds are located in the very water quality sensitive catchment of Lake Balaton. Therefore our study has been aimed to explore the potential effects of aquaculture facilities, which are connected to the important south-shore inflow Pogányvölgyi-stream. Four samplings were carried out in 2014 (March, June, September and November) in 14 localities along the longitudinal section of the stream and 11 water quality parameters were measured. Our analyses revealed that water quality changed along the longitudinal section of the watercourse and this trend could not linked to the fish ponds solely. The effect of aquaculture facilities depends on their management strategy and could characterized as a series of periodic disturbances, which affect the fish fauna (assemblage structure) of the watercourse negatively.

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INTERCONECTION BETWEEN FISHPOND MANAGEMENT AND AQUATIC MACROPHYTES

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Aquatic macrophytes play a key role in fishpond functioning, providing structures for many organisms, influencing nutrient cycles and stabilizing shores. In the Czech Republic, fishpond management intensity increased in the last 100–150 years. The intensification measures (such as supplemental fish feeding, or fishpond fertilisation and liming), as well as fish stock are suspected of affecting aquatic macrophytes. However, detailed data on their diversity and abundance in the Czech fishponds are not available from the past decades. Therefore, in-depth analysis of aquatic macrophytes in fishponds was initiated in České Budějovice Basin during the summer period of 2016. Different types of ponds i.e. main and nursery were surveyed. The hypothesis, the diversity of aquatic macrophytes is inversely related to fish stock, was tested. The diversity and abundance of aquatic macrophytes were recorded using the five-level Kohler scale. The basic physico-chemical parameters of water, i.e. oxygen, pH, chlorophyll a, and water transparency, were measured to describe their habitats. Our preliminary results showed that the aquatic macrophyte diversity was higher in nursery than in main fishponds. The interactions between aquatic macrophytes, fish and fishpond management certainly deserve more attention.

AN EVALUATION OF THE TROPHIC STATE OF SMALL WATER BODIES BASED ON THE ANALYSIS OF MAJOR MEIOBENTHIC TAXA

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MeioEco is a method for evaluating the ecological status of water bodies and rivers using the analysis of major meiobenthic taxa. Given the small sizes of meiobenthic invertebrates (up to 1 mm) and their occurrence in the superficial layer of bed sediment, these organisms are associated with the local environment, where they form characteristic clusters that are used for the evaluation of the development of the trophic status of a given water body or a given group of water bodies. Basic parameters are included in the analysis, such as: density of organisms, number of organisms per 10 cm2 of the bottom, number of identified taxa, and taxonomic balance index. We used this method to evaluate the trophic status of 9 small water bodies located within the same catchment in the area of a moraine plateau in Poland.

The analysis using MeioEco revealed the following:

1. Small water bodies are a poor environment, as confirmed by the small number of taxa and low counts of meiobenthic organisms.
2. The small water bodies we studied varied greatly in terms of ecological status, ranging from developing trophic state, through strongly developed trophic state, to the state of degradation.
3. The ecological status within the water bodies varied depending on the manner in which the shore was developed.

Based on the MeioEco analysis it may be concluded that small water bodies remain in the landscape thanks to their poor environment, but are subjected to an increasing human pressure, which may lead to their disappearance.

A COMPARISON OF THREE NON-DESTRUCTIVE METHODS TO ESTIMATE BIOMASS OF MACROPHYTES IN KETTLE HOLES

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Quantifying plant biomass in ecosystems is an essential basis for studying community relationships, transfer of energy, or turnover of biomass in food webs etc. A direct estimation of macrophyte biomass from kettle holes (pond-like depressional wetlands) is hampered by the heterogeneity of these ecosystems and their large number in the young moraine landscapes (e.g. >150.000 in North-East Germany). Hence, indirect, non-destructive methods appear to be more feasible approaches. We compared three existing non-destructive methods to estimate the biomass of four different macrophyte species typical for kettle holes in North-East Germany (Carex acutiformis, Persicaria amphibia, Phalaris arundinacea, Rorippa amphibia) in order to obtain the most reliable method. Furthermore, we examined how hydrogeomorphological characteristics of kettle holes might change the phenometric relationship.

Applying multiple regressions we found that morphological variables measured at individual plants in the field best predicted macrophyte biomass (R^2 = 0.77 C. acutiformis - 0.94 R. amphibia). Photo interpretation produced only models with predictive power between 17 % (P. amphibia) and 73 % (R. amphibia), irrespective of whether we used the Normalized Difference Vegetation Index (NDVI) calculated from near-infrared photography or the False-Colour-Method based on RGB image. The phenometric relationship was not affected by the hydrogeomorphological characteristics of kettle holes.

In accordance with our results, future estimation of macrophyte biomass in kettles holes should be based on phenometric relationship using morphological variables. These estimates should be coupled to aerial photos in order to handle the large number of kettle holes in the landscape.

POND PHYTOPLANKTON COMMUNITY IN SPECIAL NATURE RESERVE GORNJE PODUNAVLJE: FIRST REPORT

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Special Nature Reserve Gornje Podunavlje represents mosaic ecosystem with fragments of forests in flooded area of the Danube River. One of the main characteristics of this unique area is high biodiversity. However, data about phytoplankton are still lacking. Five ponds were chosen for phytoplankton sampling: Semenača and Šarkanj (both supplied by underground water derived from the Tisza River) and Široki Rit, Ribolov and Sakajtaš (supplied by water from the Danube River). Semenjača and Šarkanj have been already revitalized and the revitalization of Široki Rit was in progress during research period. The samples for chemical and phytoplankton analyses were collected monthly from May to September 2016. Biovolume of each species has been calculated, but the total biovolumes of divisions were used for multivariate analysis. Redundancy analysis clearly separates ponds with different water inflow. Semenjača and Šarkanj ponds are characterized by the highest level of nutrients and ammonium ions. Euglenophyta is the only division positively correlated with nitrates and phosphates which determines it as the most tolerant to organic load. Ribolov and Sakajtaš ponds are the most similar according to algal biovolumes and diversity, although Ribolov is strictly protected area while the anthropogenic influence is the highest on the Sakajtaš. Therefore, anthropogenic influence on Sakajtaš pond seems to be mitigated and the natural equilibrium balance of this ecosystem is not impaired. Our results suggest that phytoplankton community in studied ponds is primarily driven by water origin.

BURBOT ECOLOGY IN RESERVOIRS

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Burbot is one of the most mysterious freshwater species, typically inhabiting cold and oligotrophic waters, therefore it is highly sensitive to anthropogenic changes (e.g., euthrophication, global warming) and hence protected in many areas. Monitoring of burbot populations is difficult because of rare catch in commonly used nets. Therefore we developed a unique sampling scheme using considerate methods (visual exploration by SCUBA divers, two types of fyke nets, electrofishing) and long-lines simulating anglers practice. This scheme was tested in four Czech drinking-water reservoirs with burbot stocking for biomanipulative purposes to control planktivore species. Efficiency of the sampling methods was dependent on local conditions. Burbots were captured in three reservoirs. Young burbots were captured in the inflowing streams or in littoral zone of reservoirs with rubbles. Bigger burbots inhabited deeper parts of reservoirs. A subsample of burbots was analysed in laboratory to determine length, weight, age and stomach content. Most of the burbots were young (up to 3 years old) and the age groups corresponded to stocked fish. The preferred food items were ephemeral insects, fish and permanent water invertebrates. The other food sources were zooplankton, terrestrial insects and crayfish. Our study is unique in complex conception, starting in development of sampling procedure and ending in discussion of burbot ecology.

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COEXISTENCE OF FISH SPECIES IN METASTABLE ASSEMBLAGES

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The Eurasian beaver (Castor fiber) has been reintroduced into the Carpathian Mountains and has once again become an important factor for modifying streams. The study was conducted for 5 years, from 2008 to 2012. Fish assemblages of thirty six beaver ponds were compared with running sections of the stream. Significant differences in the fish species composition were found between beaver ponds versus the running sections of streams. The changes associated with pond aging caused decrease of Siberian bullhead (Cottus poecilopus) density. For brown trout (Salmo trutta m. fario), beaver ponds were the only location where large individuals were found, while the upstream parts of the beaver complexes provided spawning habitat and an area for fry growth. Common minnow (Phoxinus phoxinus) and stone loach (Barbatula barbatula) had higher density in ponds than in running section of streams. Species coexistence in communities means that multispecies models must close the life cycles of all populations in a community simultaneously. Only at few sites all the four fish species coexisted. At other sites populations gradually disappeared and the community consisted of only the most successful species. The decisive factors for the ichthyofauna in the mountain streams settled by beavers were local attributes related to beaver activity. Beaver affects on various fish life history stages and influences the ichthyofauna structure in streams. Analysis of fish assemblages from different parts of the beaver complex, indicated substantial variability of their structure. Our results suggest that the fish assemblages in beaver dam-and-pond complex can be considered as metastable.

FISH HABITAT SELECTION IN A LARGE HYDROPEAKING RIVER: STRONG INDIVIDUAL AND TEMPORAL VARIATIONS REVEALED BY TELEMETRY

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Habitat selection depends on individual behaviour and global behaviour (eg. species, guild). Species habitat selection models are currently based on global behaviour. To improve models and prediction of environmental changes on species dynamics, individual behaviour component comprehension is required. We compared the individual and species levels of fish microhabitat selection for three main species (barbel, n=5; catfish, n=6 and chub, n=7) of the Rhône River. These fish lived in a highly variable environment subjected to hydropeaking and locally warmed by the cooling system of a nuclear power plant. We used fixed acoustic telemetry technique in a 2-km reach to continuously survey individual over a three months period. Abiotic habitats were defined by current hydraulic conditions (water depth, flow velocity, substrate grain size, temperature) and past hydraulic conditions (dewatering risk, flow velocity variations, maximum flow velocity). Mixed-effects habitat selection models indicated that individual effects were as strong as specific effects. Models also indicated that fish selected current hydraulic conditions and past hydraulic conditions. Our results suggested that fish were able to choose the current habitat considering the spatial and temporal changes. In the reach studied, fish generally avoided fast-flowing midstream habitats and lived along the banks in areas where the dewatering risk is high. When discharge decreased, however, they selected higher velocities but avoided both dewatering areas and very fast-flowing midstream habitats. Although consistent with the available knowledge on static fish habitat selection, our quantitative results demonstrate temporal variations in habitat selection, depending on individual behaviour and environmental history.

SHORT-TERM FISH MOVEMENT BEHAVIOUR AFTER LONG-RANGE TRANSLOCATION

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Translocation is an important conservation strategy currently being used in many rivers to restore fish populations. However, due to inherent differences in source population behaviours, stress effects of translocation and homing behaviours, the successful establishment of translocated individuals to new areas is uncertain. It is also unclear how differences in flow regimes of release sites influence short-term behaviour and likelihood of successful establishment over the longer term. Here we use telemetric data to investigate post-release movement behaviour of translocated freshwater catfish (Tandanus tandanus), a listed threatened species in the northern Murray-Darling Basin, Australia. We sourced 36 adult fish from a thriving population in a reservoir, surgically implanted acoustic tags and translocated them to receiver arrays deployed in two nearby riverine reaches with differing flow regimes; one heavily altered and one restored by environmental flow releases. We monitored fish movement behaviour over a six month period post-release and compared linear range size, distance moved and habitat associations between translocated fish in the regulated and restored sites. We found that a subset of translocated fish remained close to the release sites and appeared to establish local home ranges, whereas others undertook dispersal movements over varying spatial scales. Differences in movement behaviour between release sites were interpreted with respect to environmental flow releases at one site but not the other. Future work will monitor reproduction success of these translocated wild adult fish to confirm if translocation and environmental flow restoration is a suitable conservation strategy to re-establish fish populations within their natural ranges.

OTOLITH STRONTIUM ISOTOPE RATIOS IDENTIFY RECRUITMENT SOURCES OF GALAXIIDS IN THE LOWER WAIKATO RIVER CATCHMENT, NEW ZEALAND

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Information on the recruitment sources sustaining fish populations is integral to their effective management, providing insights into early habitat requirements, population connectivity, and potential source-sink dynamics. However, the difficulty of tracking tiny larval and juvenile fish makes identifying recruitment sources particularly challenging for amphidromous species, which spend their larval period in a lake or the sea before migrating into streams as juveniles. We used Sr87/Sr86 ratios of otoliths and water samples to attempt to determine the larval origins of large galaxiids in the lower Waikato, a catchment with many potential larval sources including the sea and a complex system of riverine lakes. To identify larval origins, we compared Sr87/Sr86 ratios in the larval zone of otoliths with water samples from all potential larval sources. Nearly all fish examined had reared in lakes rather than the sea. While a few lakes had similar isotopic ratios which prevented accurate classification, discriminant function analysis classified the majority of fish to a larval rearing habitat with a high probability (>70%). Further, nearly all of these fish were classified to the nearest downstream lake from their location of capture, indicating limited dispersal between sub-populations. Subsequent larval trawls confirmed relatively high abundances of larvae rearing in those lakes identified as major sources of recruits. These results demonstrate the potential for isotopic analyses of otoliths to be used in identifying sources of recruits to fish populations, and provide information crucial to the management and conservation of amphidromous fishes in the lower Waikato river catchment.

THE SCALES OF VARIABILITY OF STREAM FISH ASSEMBLAGES AT TRIBUTARY CONFLUENCES

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Tributary confluences play an important role in the dispersal of organisms, and consequently, in shaping regional scale diversity in stream networks. Despite their importance in dispersal processes, little is known about how ecological assemblages are organized in these habitats. We studied the scales of variability of stream fish assemblages over three seasons using a hierarchical sampling design, which incorporated three tributaries, three sites at the mouth of each tributary and using four sampling units at each site. We found strong scale dependent variability in species richness, composition and relative abundance. Most of the variation was accounted for by the interactive effect of season, between stream and between site effects, while habitat structure of the sampling units had a relatively minor role. Species richness showed a continuous decrease from the mainstem river in most cases, while species composition and relative abundance changed less consistently along the longitudinal profile. Consequently, we found that not only the junctions presented a strong filter on the species pool, but some species were filtered out if they passed this critical habitat bottleneck. Overall, our results suggest high variability in fish assemblages across multiple scales at tributary confluences. Environmental management should take a more critical care on the filtering role of tributary confluences in species dispersal, for better understanding patterns and processes in the branches of dendritic stream networks.

OXYGEN-DEPLETION_AND_IBERIAN-BARBEL.DOCX“ CONTAINS ONLY THE TEXT OF THE ABSTRACT.

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Water abstraction, discharge of organic wastes, and diffusion of agricultural fertilisers are common problems in Mediterranean river systems. These cause a depletion of dissolved oxygen and lead to hypoxic conditions which affect aquatic organisms. Among others, low oxygen concentrations impact fish behaviour. However, little is known about the effects of deoxygenation on the behaviour of Mediterranean freshwater fish. This study analysed the effect of three different dissolved oxygen levels (normoxia, 50 %, 15 %) on the behaviour of the Iberian barbel, Luciobarbus bocagei, in a laboratory flume. Each treatment level consisted of five replicates of a school of five wild-caught fish each. By tracking individuals through video analysis, we studied swimming movements as well as the spacing between fish in a school. Results show that swimming velocity, acceleration, and distance travelled were significantly different between the three treatment levels. Group size showed distinctions in regards to the average maximum distance between the fish. Minimum and mean distance between individuals of a group, however, did not differ between the treatments. These findings reveal that increased oxygen depletion reduced overall school integrity, while smaller groups of fish tended to stay close together. Overall, our experiments indicate that depletion of dissolved oxygen affects the behaviour of Iberian barbel, having implications for its ecology, survival, and fitness.

PATTERNS OF HABITAT USE OF THE ENDANGERED FISH SPECIES SARAMUGO, ANAECYPRIS HISPANICA, AND THE INVASIVE BLEAK, ALBURNUS ALBURNUS: IMPLICATIONS FOR NATIVE FISH FAUNA CONSERVATION.

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The Bleak (Alburnus alburnus) is an invasive fish occurring in high density in many streams and rivers of the Iberian Peninsula, namely in the Guadiana basin. Considering its invasive success, the coexistence with native species can led to negative impacts. Although this species has been considering a biological threat, there is still a lack of knowledge on many aspects of its bio-ecology in Mediterranean climate streams. This study was developed under the Life Project for the Conservation of Saramugo (Anaecypris hispanica) in the Guadiana River Basin and aimed to evaluate the potential impact of the Bleak on the Saramugo populations, considering the patterns of habitat use and distribution. Data were collected in the Guadiana river basin during the spring of 2015 and 2016. The patterns of habitat use, habitat preferences and overlap were quantified. The spatio-temporal variability of the Bleak captures was also evaluated. Saramugo exhibited habitat preferences for deep pools, medium/deep runs and fast riffles and the Bleak showed preference for medium / deep pools and medium/deep runs, resulting in a high habitat overlap between both species. Substrate type and vegetation elements were important for both species, though with distinct preferences. The Bleak performed seasonal movements in the river network that seems related to a dispersal strategy to assure the occupation of new stream areas. The obtained results contribute to support decision-making on the implementation of effective measures that selectively benefit the native fish fauna conservation.

IS SALMONID MIGRATION INITIATED BY JUVENILE INTRA-SPECIFIC COMPETITION?

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Plasticity in animal migration is a key attribute that allows for flexible responses to unstable environments and climate change. Salmonids are classic examples of migratory organisms that exhibit a variety of life histories, enabling them to exploit a wide variety of environments across mid- to high-latitude environments, and contributes to their success as invasive species. One of the most variable and invasive salmonid species is brown trout Salmo trutta. Brown trout exhibit a variety of life strategies, migratory tactics and may occupy lentic, lotic, estuarine and sea environments as adults. However, a common feature of all brown trout life histories is that spawning and early juvenile stages always occur in cold, well-oxygenated streams. If downstream juvenile migration occurs, then upstream migration back to spawning streams is required to complete the brown trout life cycle. Our study focused on the factors initiating juvenile downstream migration, specifically testing the hypothesis that juvenile competition for resources initiates migration. Juvenile trout density, growth, migration intensity and food supply were measured in situ in streams in which migratory or resident trout population were present. Preliminary assessments suggest that as juvenile brown trout grow, population densities will become unsustainable in streams that support migratory populations, whereas juvenile trout densities are significantly lower in streams supporting resident populations. The results of bioenergetic modeling predicting growth in relation to temperature and food supply will be presented, and compared to actual juvenile brown trout densities present in migratory and non-migratory streams over summer and into autumn.

FISH LEARNED MOVEMENTS IN A LARGE REGULATED RIVER

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Habitat selection and mobility are major elements of fish population biology. However, little information is available about the behavioral ecology of holobiotic fish in European large rivers. We assessed micro-habitat selection and mobility patterns of two native species of cyprinids (barbel and chub) and of an exotic fish species (catfish) in the heterogeneous hydraulic and thermal conditions (modeled in two-dimensions) of a reach of the large hydropeaking Rhône River, locally warmed by the cooling system of a nuclear power plant. In 2009, we used fixed acoustic telemetry techniques to survey 5 barbels, 7 chubs and 6 catfishes signaling their position every 3-4 s over a three-month period for assessing fish micro-habitat selection in a 2 km-reach. In 2010, we used an active acoustic equipment to track 37 barbels, 23 chubs and 13 catfishes for seven months on a weekly basis for assessing longitudinal home ranges and movements between preferred residence areas in a 35 km-reach. Seven of the individuals tagged in 2009 were also tracked in 2010 and their multi-scale locations enable to better understand their “Fishscape” within the “Riverscape”. In the Rhône River, the observations of movements along potential preferential routes suggest that fish can memorize the bathymetry and variations of environmental configurations (hydraulics and temperature) of the reach. At a local scale, fish modify their habitat selection when discharge changes in selecting „least constraining“ conditions. At a larger scale they are able to travel rapidly between known habitats.

THE ROLE OF MOTIVATION ON FISH MIGRATION: HOW DOES CYPRINID PERFORMANCE CHANGE IN A VERTICAL SLOT FISHWAY IN DISTINCT SEASONS

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The motivation for fish migration is an essential aspect for the management of fishways, however it still remains uncertain or not studied. The vast majority of fishway studies on potamodromous cyprinids are conducted during the migratory season. To understand the role of fish motivation on fishway studies, the present study proposes to assess the performance of the Iberian barbel (Luciobarbus bocagei, Steindachner, 1864) a large-bodied potamodromous cyprinid in a vertical slot fishway (VSF) in distinct seasons. The study was conducted in a full-scale experimental VSF under two different discharges (Q=110 L.s-1and Q=81 L.s-1) in Spring (migratory season) and in Autumn. Results show that, no differences were detected between seasons in the number of upstream movements and passage successes of the Iberian barbel. Differences were, on the other hand, detected in the plasma lactate concentrations (mmol.L-1) between seasons and also between tested and control fish. This suggests that for potamodromous cyprinids, the assessment of fish passage performance in fishways does not need to be limited to the migratory season. Furthermore, lactate differences detected between seasons suggest that fishway studies should, in fact, be conducted in distinct seasons to account for physiologic adjustments that may occur in potamodromous cyprinids. These findings may lead to an along-the-year adaption of the operation regime of fishways to be compliant with the behavior of the target species.

SEASON AND TROPHIC LEVEL CONTROL FATTY ACID COMPOSITION AND CONTENT OF COMMERCIAL FISH SPECIES FROM A MESOTROPHIC RESERVOIR

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We studied four commercial fish species from a mesotrophic water body, Krasnoyarsk Reservoir (Siberia, Russia). We tested the hypothesis that differences in trophic levels of piscivorous and omnivorous fish species control levels and contents of individual fatty acids, including conditionally essential eicosapentaenoic (20:5n-3, EPA) and docosahexaenoic (22:6n-3, DHA) acids. In addition to fatty acid analysis, we also used conventional measurements, such as analyses of stomach contents and carbon and nitrogen stable isotopes in the fish muscles. Differences in fatty acid composition and stable isotope ratios allowed to separate omnivorous (roach and bream) and piscivorous (Eurasian perch and pike) species. We found that the piscivorous fish contained significantly more DHA, compared to the omnivorous fish species. This fact likely means a higher trophic transfer efficiency for DHA. Additionally, an impact of seasonality on the fatty acid composition of two fish, perch and roach, was revealed. This impact was probably caused by direct and indirect effects of water temperature and seasonal changes in the fish diet. Regarding content of EPA + DHA sum per mass unit of muscle tissues (filets) as the indicator of nutritive value for humans, pike had the highest nutritive value among the studied fish species.

FUNCTIONAL REDUNDANCY AND VULNERABILITY OF FISH ASSEMBLAGES IN EUROPEAN RIVERS UNDER MULTIPLE STRESS.

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A multitude of human-induced stressors are currently affecting taxonomic community structure, most often leading to a generalised biodiversity loss. Species loss, to varying degrees, also implies the loss of ecological functions that are more directly involved in ecosystem processes and services. Hence, understanding and predicting how functional attributes of biotic communities are affected by environmental stressors is crucial to implement effective environmental management actions. In this work we used a dataset of 2189 sites located in 14 European countries to investigate the effects of both natural environmental gradients and multiple stressors in several functional attributes of fish assemblages that are potentially related to their vulnerability. The functional structure of fish assemblages was based on five complementary traits: fish size, vertical position, spawning habitat, trophic group, and swimming mode. Functional redundancy was assessed through simulations of species loss and how this loss would affect functional richness. An index of taxonomic vulnerability, based on both functional redundancy and species extinction risk, was then computed. The effect of different combinations of stressor types, related to morphology, hydrology, water quality and connectivity, were assessed after accounting for the natural environmental variability, using Generalized Linear Mixed Models. Functional attributes and vulnerability were shown to be strongly affected by the natural environmental gradient. A strong interaction between stressors and natural environment was found, suggesting an idiosyncratic nature of assemblage responses to multiple stressors at the European scale. Hence, results suggest that best management practices to reduce assemblage's vulnerability may not be generalizable at the European scale.

ONTOGENETIC DEVELOPMENT OF SCALE SHAPE OF GIBEL CARP (CARASSIUS GIBELIO BLOCH, 1782)

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Taxonomic classification of fish species is possible based on their shape. This way of classification could be difficult, while in fishes the allometric growth is typical, which means, the body parts grow asymmetrically. Several studies analyzed the body shape changes during the growth in different fish species. The possibility of species and population level severability of fishes based on scale shape was proved recently, however there are still a lack of information regarding the usability of this method. Therefore our study was addressed to study the effect of age on the scale shape. Seven age groups (0+-6+) of Gibel carp (Carassius gibelio) scale shape was analyzed to assess the effect of ontogenetic development. The impact of scale size was significant on the shape ($p<0.001$), it was responsible for the 3.47% of the total shape variance. The age groups were significantly different with high reliability (average 91.6%), except age groups 3+-5+ and 4+-5+. Our results revealed the significant impact of age on scale shape, which supports the previous observations: scale shape shows ontogenetic variability. In case of gibel carp, this species-specific shape was reached at the age 3+. This observation could be crucial by the investigation of scale groups with different age structure, while age distribution itself can significantly distort the results and possibly mask the environmental and genetic differences.
This study was supported by the GINOP 2.3.2 – 15 – 2016 – 00004 project: „Establishing the sustainable angling-aimed management of Lake Balaton.

SEASONAL AND DAILY PROTANDRY IN A CYPRINID FISH

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In polygynandrous mating systems where females have a limiting potential reproductive rate, males can increase their mating chances through high courting investments. Many species gather for reproduction, and such gatherings is where male competition is the strongest. In these systems, males may increase the number of mating opportunities by early arrival to the spawning ground. Here, we tested by passive telemetry how male asp, Leuciscus aspius, time their arrival in relation to their mates and the operational sex ratio. Males arrived to the spawning ground five days earlier on average and left four to five days later than females. Males also exhibited higher detection frequencies per hour and spent a longer time in the spawning ground. Both sexes performed daily migration between a staging ground (standing water, low energy costs) and the fluvial spawning ground (high energy costs). Spawning culminated twice a day with a major peak at sunset and a minor peak at sunrise. Males arrived 48 minutes before females in the major evening spawning peak, while females preceded males in the morning spawning peak by 26 minutes. The degree of daily protandry was not correlated with the current sex ratio.

Keywords: fish reproduction, mating behaviour, polygyny, polyandry

DO HIGHLY-FECUND MIGRATORY SPECIES WITH LAKE-REARED PELAGIC LARVAE DOMINATE NON-MIGRATORY SPECIES IN STREAMS UPSTREAM OF LAKES?

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Lakes influence the distribution and structure of freshwater fish fauna in catchments. Whilst the impact of lakes on downstream fish communities is well known, changes in upstream fish communities have received little attention. Particularly in species exhibiting migratory and non-migratory life-history strategies. We examined the relationship between lakes and distribution of a migratory species with small pelagic larvae (Galaxias brevipinnis), and a species complex of non-migratory galaxiid species in streams flowing into high-altitude lakes in South Island, New Zealand. Fish and environmental data were extracted from a series of databases to develop a final dataset of stream sites above 20 large, inland lakes. Additionally, fish data from large free-flowing streams were analyzed to compare species distribution in landscapes with and without lakes. We tested the hypothesis that fecund migratory species would dominate in catchments upstream of lakes, whereas non-migratory species would dominate further upstream from lakes or in catchments without lakes. Inclusion of the lake significantly improved the prediction of both migratory and non-migratory species upstream of lakes compared with the models based only environmental conditions of the adult habitats in streams. While the non-migratory Galaxias taxa were dominant throughout the catchments without lakes and in streams approximately >20km upstream of lakes, migratory G. brevipinnis dominated streams near lakes. The fecundity advantage that G. brevipinnis gains close to the lake larval rearing habitats likely excludes non-migratory galaxiid species in streams near lakes, emphasizing the importance of considering different life-history strategies when assessing distribution of fish species in lake-influenced landscapes.

Keywords: inland lakes, distribution, life history strategies, migratory and non-migratory galaxiids

DIETARY NICHE AND TROPHIC POSITION OF SYMPATRIC ASP AND PIKEPERCH IN TWO ARTIFICIAL LAKES WITH CONTRASTING MORPHOMETRY

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The feeding ecology of sympatric asp Leuciscus aspius and pikeperch Sander lucioperca populations were examined in two reservoirs with contrasting morphometry, using both gut content and stable isotope analyses. Gut content analysis identified terrestrial insects as the common prey for both young-of-the-year and older asp, but they were never eaten by pikeperch. In the reservoir with a high perimeter-to-area ratio, asp guts generally exhibited higher occurrence frequency of terrestrial insect prey. However, stable isotope analysis indicated that terrestrial insects were an important energy source only for young-of-the-year asp, whereas older asp relied mainly on fish prey in both reservoirs. Similarly, aquatic invertebrates were important for young-of-the-year pikeperch, while older pikeperch assimilated mostly fish in both systems. The stable isotope-derived trophic positions were fairly similar between asp and pikeperch, and increased significantly with predator size. Asp and pikeperch populations in the large reservoir had considerably broader isotopic niches than those populations in the smaller reservoir. Within a system, the isotopic niches of both species overlapped to only a limited extent. This indicates that although older asp and pikeperch were largely piscivorous and fed at similar trophic levels they probably efficiently partitioned foraging habitats and prey fish resources.

PHYTOLOSS 2.0 - AN OPEN-SOURCE DATABANK TOOL FOR MANAGEMENT AND ANALYSIS OF ZOOPLANKTON DATA: WHAT IS HAS TO OFFER

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Zooplankton was excluded from the EC-Water Framework Directive and 'forgotten' was the role of food web interactions for water quality parameters. With our aim to introduce zooplankton into the EC-Water Framework Directive we need to implement accepted methodological standards as well as a tool box of meaningful indices and visualizations. The development of a nation-wide zooplankton databank (PhytoLoss project, ACCESS-based) in Germany linked to the corresponding phytoplankton databank PhytoSee already helped to standardize sampling procedures, file formats for data exchange and backup, coding of taxon names, defining a minimum level of taxonomic determination per species and factors for calculation of zooplankton biomass. However, the main purpose was to calculate grazing indices and estimating the impact of top-down food web interactions on parameters of ecological quality adding to the usual interpretation of nutriens loads. PhytoLoss 2.0 has now become a general platform for the management and analysis of metazooplankton (rotifers, crustaceans) data. With a click it calculates indices of food quality, grazing impact, fish predation (via zooplankton size) and predation by carnivous cladocerans and provides an automated comments function with radar plots for visualization of the most important parameters. More is under way e.g. using taxonomic data and indicator species eventually providing 'zooplankton profiles' per lake and lake type. We will give an overview about the current features of PhytoLoss and give an example how you might identify phases of grazing-driven algal blooms. Still open for discussion is the meaning of 'reference conditions' regarding zooplankton.

PRELIMINARY ASSESSMENT ON CILIATE DIVERSITY OF SALINE LAKES (BOLLUK, ACIGÖL, TERSAKAN, TUZ) FROM KONYA BASIN, TURKEY

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Although, in Turkey, lakes cover an area of more than 500 ha, few studies have been conducted to examine the effects of environmental factors on ciliate biodiversity. Therefore, Konya Closed Basin, being an important one, affected by intense anthropogenic pressure, was investigated.

Konya Basin is located in the southern of Central Anatolia and covers an area of 53,000 km^2 which includes various of ecosystems such as; rivers, lakes, potholes, reeds, marshes, meadows, pastures and agricultural areas. The region is substantial, with a non-outlet basin containing important sedimentary archives which permit the reconstruction of Late Quaternary palaeohydrological and palaeoclimatic variations of which all the rivers are over only to lakes or marshes.

The seasonal distribution of ciliates were studied through a data set, comprising the taxonomic composition and the abundance distribution. Biotic and environmental variables were evaluated based on one year time series of monthly monitoring from january 2016 to december 2016 at 3 lakes and 11 stations which have different salinity gradients

The ciliate communities were characterized by the presence of freshwater, estuarine and marine species with a total of 205 taxa belonging to 14 divisio (Cyrtophorida, Gymnostomatida, Heterotrichida, Hymenostomatida, Hypotrichida, Nassulida, Oligotrichida, Peritrichida, Pleurostomatida, Prostomatida, Suctoria, Scuticociliatida, Sessilida, Odontostomatida). In high salinities, the lakes showed a restricted diverstiy. However, not only ciliates but also a significant flagelatte population, basically dominated by euglanoid specimens, were identified in high salinities.

According to statistical results, both time of sampling lakes (seasons) and sampling sites jointly had significant effect on ciliate densities. Additionally, the salinity gradiendts distinctly affected the abundance and variety of ciliates species, in which, the highest number of taxa were recorded in Acıgöl and the lowest were in Tuz Lake.

Even though analyses are still ongoing, the first findings were suggested that salinity as an environmental parameter was affecting the ciliate species diversity in the observed lakes.
Research supported by the Scientific and Technological Council of Turkey with the project of 115Y492.

RS14 – Poster

A PRELIMINARY STUDY ON DETERMINING THE OPTIMUM ENVIRONMENTAL CONDITIONS OF FABREA SALINA (CILIPHORA:HETEROTRICHIDA)

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Objective: Fabrea salina is a pelagic and hypersaline ciliate having potential to be used as live food source in commercial aqaucultures. Therefore; in this study, optimum environmental conditions of this ciliated protozoa species were investigated on its natural habitat.
Methods: All the samples were collected between December 2015-May 2016 monthly from four different lakes (Acıgöl-Konya, Acıgöl-Denizli, Bolluk, Tersakan) by using 10µm plankton net and counted by using subsampling method. Morphological characters for the species were identified by live observation, defined by the evaluation of morphometric measurements and counts which were performed digitally by LAS image manager system Illustrations of the specimens were by free-hand sketchs and micrographs.
Results and Discussions: The total F. salina abundance varied between 1-447.6 cells/ml with 9.1-26.71°C temperature, 7.98-9.14 pH and 29.34-114.96 ‰ salinity. The largest number of ciliates were found at 15.34 °C, pH 8.35 and 75.71 ‰ salinity. Individuals were mostly distributed by number among 14-24 °C, pH 8.16-8.87, 60-80 ‰ salinity. Consequently, F. salina can be used as a live food source because it is a very tolerant halophilic ciliate species and can live extensive environmental conditions but according to abundance results, aquacultures have to be organised for large stock numbers.
Research supported by the Scientific and Technological Council of Turkey with the project of 115Y492.

ZOOPLANKTON INFLUENCE ON PHYTOPLANKTON BIOMASS AND COMMUNITY STRUCTURE IN RIVERS

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To predict and prevent harmful algal blooms in rivers it is essential to understand all processes of their development and termination step by step.
It has been established, that factors such as residence time, water temperature, nutrient chemistry and light alone do not completely explain river phytoplankton dynamics.
This study focused on biological control of phytoplankton dynamics, mainly on zooplankton 'grazing' effects.
From March-October 2015 weekly surveys were carried out on the River Thames, UK. Zooplankton were counted and identified to species or genus levels from nine sites across the catchment, including three tributaries.
The zooplankton were dominated by rotifers, with a maximum of approximately 8000ind./L recorded in summer in the lower-Thames. Micro-crustaceans were generally found in larval stages and did not develop significant densities (maximum of 125ind./L in spring in the middle-Thames) probably due to low residence times.
A series of laboratory and monthly field-based experiments were undertaken in the growing season of 2016, to test the significance of grazing impact on algal dynamics at multiple sites across the Thames. In all experiments, phytoplankton and zooplankton diversity and densities were maintained close to their natural conditions. Temperature, light and nutrient concentrations were monitored.
Experimental data revealed a moderate to non-significant grazing effect throughout the spring-summer period, with indications of small numbers of zooplankton actually promoting algal growth.
Microscopic examination of fresh samples highlighted a rise in algal mortalities due to algicidal bacteria and fungal parasites. Further work is being done to explore this potential explanation of high algal mortalities.

REPEATED FLOOD DISTURBANCE ENHANCES ROTIFER DOMINANCE AND DIVERSITY IN A ZOOPLANKTON COMMUNITY OF A SMALL DAMMED MOUNTAIN POND

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The zooplankton community in a relatively small and mountain pond was studied during the spring growing season. To investigate which factors operate in the community structure, we explored several physical conditions, such as high inflows, and the biotic dynamics of the main zooplankton groups (i.e., rotifers, cladocerans and copepods). Two extreme flood events occurred during the investigated period and caused dramatic changes in physical conditions and reduction of the planktonic community abundances. The short period between both high-flow events was enough for the recovery of microplankton, but not for the metazoan zooplankton. Our results are in agreement with the common situation in which high flood events commonly favour rotifers over crustaceans, likely due to rotifer species have great colonization ability and grow faster. However, we found that the dominance of rotifers over crustaceans in our system is evidenced by an extremely, unusual high ratio between their abundances. Here, we discuss the results in order to explain the great dominance of rotifer species in the zooplankton community.

IN SITU ABIOTIC FACTORS THAT FAVOR OCCURENCE AND SPATIAL DISTRIBUTION OF CYANOBACTERIA FROM DANUBE DELTA

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Freshwater species known for being able to produce toxins such microcystins, are frequently signaled in the shallow eutrophic lakes of the Danube Delta and potential toxic blooms may occur anytime. This study targeted to (1) highlight the occurrence and distribution of cyanobacteria with toxic potential (based on taxonomy) in relation with in situ abiotic factors from 28 lakes studied between 2012-2014 and (2) to ascertain if one of the abiotic parameters could represent a key factor that promote their presence and dominance. The expectation was to find a distinctive pattern for each lake complexes based on the connectivity and similarity referral to cyanobacteria community composition, mainly those with toxic potential; we predict that the most distinctive one will be Rosu-Puiu lake complex because here was previously recorded the highest cyanobacterial biomass. The forecast was to obtain a correlation regarding the relationships of abiotic parameters and cyanobacteria and to identify some threshold values that could explain, precede or favor any potential toxic mass development of cyanobacteria. Results reveal that conductivity, light intensity, oxygen concentration, temperature, depth and water flow were the main drivers but their contribution to determine the density and diversity of cyanobacteria was different among the years, seasons and lakes. The time-related environmental variables that trigger the overall significant changes in the Cyanobacteria genera densities are the depth of the lake, temperature of the water, pH and the transparency. This work was supported by Swiss Enlargement Contribution, project IZERZ0 – 142165, “CyanoArchive”, in the framework of the Romanian-Swiss Research Programme.
Keywords: Biophere Reserve, Environmental Parameters, Eutrophication, Shallow lakes, Toxic Cyanobacteria

CHARACTERISTICS OF ZOOPLANKTON COMMUNITY STRUCTURE IN POLISH LAKES IN REFERENCE CONDITIONS

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Zooplankton is an integrative biological component of pelagic ecosystems. It acts as both the main consumer of phytoplankton and the valuable food source for planktivorous fish. Eutrophication has a considerable impact on the taxonomic, size structure, abundance, and biomass of zooplankton, thus changes in community may serve as early waring indicators of water quality deterioration. This group of organisms, however, has not been included in the EU Water Framework Directive (WFD) as a biological quality element required in lake ecological status assessment. In my study, I attempted to develop a zooplankton multimetric to be applied in assessing the ecological status of lakes in Poland.
The aim of the study was to describe the characteristic of zooplankton community composition for Polish lakes that are in near-pristine conditions and largely unaffected by anthropogenic pressures (reference lakes). Establishing reference conditions is essential for performing ecological status assessment of surface waters according to WFD.
The study was carried out in 2012-2015 in selected water bodies that meet the criteria of reference sites. Integrated samples were collected from the epilimnion layer from the deepest part of each lake, during the summer stagnation period. Based on the collected data, background water quality and the characteristics of zooplankton community in un-impacted lakes were defined. Moreover, the values of zooplankton trophic indices based on qualitative and quantitative composition structure associated to reference condition were determined. The results will serve as a starting point for the development of the method for lake ecological status assessment based on zooplankton.

MIXOTROPHY IS QUESTIONED UNDER GLOBAL CHANGE: UVR INDUCES NEGATIVE EFFECT AT HIGH TEMPERATURES

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Mixotrophy is a nutritional strategy between autotrophy and heterotrophy which allows mixotrophic protists to adapt to a wide gradient of environmental conditions embracing changes in temperature (T) and light quality. The increase in T is expected to favor mixotrophic algae in relation to photoautotrophs, due to an enhancement of their heterotrophic metabolism, including phagotrophy ability. On the other hand, it is known that UVR damages photoautotrophs more than mixotrophs; however, the interactive effects of both factors have been scarcely evaluated. Our objective was to determine the combined effects of a greater T and high UVR fluxes on the primary production, respiration and bacterivory (when applicable) of two protist organisms, one photoautotroph and other with mixotrophic metabolism. Our hypothesis is that mixotrophy is a functional trait favored by the greater T and UVR, which jointly will augment bacterivory rate. Our results showed a higher net (NPP) and gross (GPP) primary production of the mixotrophic algae compared to the photoautotroph, both under UVR or increased T (as single factors) and their interaction (UVR×T). However, UVR×T exerted a positive effect on photoautotrophic algae but negative on mixotrophic metabolism, decreasing bacterivory and NPP, and increasing respiration (R), being these responses mainly leaded by UVR. This study highlight the UVR role as the main driver factor in the response of mixotrophic metabolism facing global change.

VERTICAL HETEROGENEITY OF PLANKTON IN LAKES OF DIFFERENT TROPHY: DIFFERENTIATION AMONG EPI-, META- AND HYPOLIMNION STRATA

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The changing climate can affect both, the length of the water stratification period (earlier stratification onset and later fall overturn) and temperature of thermal layers in lakes. The phytoplankton density and distribution depend on the availability of the physico-chemical characteristics of the lake waters (bottom-up control)as well as predation plankton animals (top-down control). Alterations of the thermal strata can impact the main driving forces controlling the plankton structure in freshwater ecosystems. Based on the assumption that both of these bottom-up and top-down processes act in different way in temperature, oxygen and light vertical gradients our aim was to determine the relationships between phyto- and zooplankton within different thermal strata in various lake trophic conditions. In summer 2012, we examined 15 dimictic lakes located in the Masurian Lakeland (north-eastern Poland) of various morphometric and representing two groups of trophic conditions: in low and high trophy. We analyzed the taxonomic composition, size structure and biomass of phyto- and zooplankton and physico-chemical conditions of waters in different strata. We searched for the differences between phyto- and zooplankton characteristics between layers with high and low trophy.

DO CLIMATE AND LAKE ENVIRONMENTS HAVE MORE INFLUENCE ON LONG-TERM VARIATION IN ZOOPLANKTON COMMUNITY OF BOREAL SHIELD LAKES THAN CLEARCUT LOGGING?

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Watershed clearcut logging in Canadian forests is a major threat for the ecological integrity of boreal lakes. To disentangle the effects of natural variation in climate and lake environments from those of watershed logging disturbances, we monitored zooplankton community changes in three boreal lakes of the Canadian Shield in Ontario, 5 years prior and 8 years after logging, in comparison to three unperturbed lakes. This is the first study assessing long-term variation (> 10 years) in zooplankton community in boreal oligotrophic lakes subjected to logging disturbances. We tested the hypothesis that long-term (13 years) natural variation in climate and lake environments will be more important drivers of zooplankton community changes than the impacts of logging disturbance, using a short-term MBACI design, as well as space/time interactions and asymmetric eigenvector maps (AEM). Year-to-year variations in zooplankton abundance were important and represented almost an order of magnitude whereas among-lakes spatial variation was stable through time. Breakpoints in time series of zooplankton abundance in each lake occurred independently of clearcut logging disturbances. Climatic and lake environment conditions were the most important drivers of long-term variation in zooplankton community. Our study suggests that future climate warming will be a strong driver of changes in zooplankton community of Canadian Shield lakes, enhancing the effects of watershed logging disturbances.

DAPHNIA AND CERIODAPHNIA LIVING NICHES IN LONG AND DEEP RESERVOIRS

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The water fleas of the Daphnia longispina species complex are more or less permanent components of zooplankton occurring in large European water bodies throughout the whole year. The occurrence of Ceriodaphnia quadrangularis may not be so permanent, since the occurrence of this species is more probable in the vegetative period than in winter. According to the literature Daphnia and Ceriodaphnia differ in the structures of their filtering apparatus, suggesting that there are also qualitative differences in their food sources. In surveys of eleven Czech reservoirs we have found that in natural reservoir conditions Ceriodaphnia have greater preferences for upstream reservoir locations. When Daphnia and Ceriodaphnia both occur near the dam there is significant spatial depth segregation, Daphnia being more abundant in the epilimnion while Ceriodaphnia are more numerous in the metalimnion. This depth patterning between Daphnia and Ceriodaphnia is also visible on longitudinal transects of canyon shaped reservoirs. Daphnia and Ceriodaphnia also occur together in shallow water bodies from where we do not have any information on their spatial segregation. Our principal question for further research is whether this spatial differentiation in deep waters results purely from their preference for different depths with different food sources, or whether Daphnia and Ceriodaphnia species have some “active communication for allocation of sphere of interest/influence”

SURVEILLANCE MONITORING OF NORWEGIAN LAKES: ASSESSMENT OF ECOLOGICAL STATUS BASED ON CRUSTACEAN ZOOPLANKTON

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Assessment of ecological status of lakes according to EU's Water Framework Directive (WFD) requires high quality monitoring data of phytoplankton, macrophytes, invertebrates and fish in addition to hydro-morphological and chemical parameters. However, in the monitoring and assessment of lake' acidification based on littoral macroinvertebrates and fish, we have experienced major methodological challenges. Surveys of planktonic and littoral microcrustaceans (Cladocera and Copepoda) have revealed valuable information for the environmental surveillance, because these groups 1) include species with specific environmental requirements and restricted distributions as well as species which occur in a wide range of standing waters over a large geographical area; 2) are well known with regards to geographical distribution and environmental demands; 3) have a generally high capacity for dispersal which should facilitate quick responses to remedial actions; and 4) their sampling requires only modest expenditure of time and equipment. In Norway, this group has been included in the monitoring program on long-range transported air pollutants since 1996 and in the national surveillance-monitoring program of lakes c.f. the WFD since 2009. Based on a national dataset on 3100 lakes, the sensitivity to acidification and eutrophication, respectively, have been indicated for many of the species recorded in Norway and a system for ecological status assessment of Norwegian lakes are under development. This assessment system represents a cost-efficient alternative to the assessment of lakes based on the monitoring of littoral macroinvertebrates. This presentation will give an overview of the methodology for monitoring and ecological assessment of crustacean zooplankton in Norway.

DOES THE LENGTH OF LIGHT EXPOSURE MATTER FOR ALGAL BIOMASS DEVELOPMENT IN TEMPERATE RIVERS?

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Phytoplankton produces the majority of organic matter in most of the aquatic ecosystems. Riverine phytoplankton in the temperate zone has special features, contrary to lakes where nutrients are considered primary limiting factors for the growth of algae, in most rivers both nitrogen and phosphorus are available in excess and their concentrations meet the demands of the phytoplankton . The other important feature is the residence time which is one of the most important system properties in rivers which has profound implications for riverine phytoplankton . In upper river segments where residence time is not sufficient for the development of large phytoplankton biomass, the planktonic assemblages consist primarily of benthic elements (mostly pennate diatoms) entrained from various surfaces of the river bed. This so-called rhithroplankton is continuously enriched with euplanktonic elements downstream, and in the middle and lower sections of large river characteristic high biomass assemblages dominated by euplanktonic elements are formed. However, there are some groups of algae that can cope with these difficulties posed by the fluctuating physical properties of the environment such as green algae and planktonic diatoms which are the most frequently dominating elements of the riverine phytoplankton. We hypothesised and proved that light exposure has a significant effect on river phytoplankton, and the river type has a pronounced influence on the relationship between phytoplankton biomass and light exposure.
We identify two main type a relationship, a hump-shaped and an increasing tendency. The two relationship types reflect different river types and sections, such as rihthral rivers with coarse riverbed substrate and potamal rivers with fine riverbed substrate.

SEASONAL STOICHIOMETRY OF THREE DOMINANT MICROCRUSTACEANS IN THE SLAPY RESERVOIR (CZECH REPUBLIC)

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Seasonal dynamics of crustacean zooplankton body carbon (C), nitrogen (N), and phosphorus (P) content in relation to seston stoichiometry was analysed in the eutrophic, warm monomictic Slapy reservoir during the growing season of 2015. Although crustacean zooplankton consisted of 18 species, we focused on the elemental content of dominant zooplankton taxa, namely Daphnia (Cladocera), Cyclops (Copepoda: Cyclopoida) and Eudiaptomus (Copepoda: Calanoida), which differ in their feeding ecology. While the seston C:N ratio remained relatively stable during the whole growing season, moderate P limitation was indicated in the late summer when both the N:P and C:P molar ratios peaked at 41 and 300, respectively. While the crustacean body C content was relatively stable throughout the season, a pronounced variation in both the N and P content was revealed. Daphnia body P content in adults continuously increased until the highest value obtained (21 mg P g–1 corresponding to 2.0% of body P) in late April. The sharp decrease by one half in June (1.0% of body P) was followed by more or less stable body P content until the end of the growing season. Juvenile daphnid P content was generally higher than those of adults. The order of taxa according to the increasing C:P was as follows: Cyclops females without ovisacs, juvenile Daphnia, adult Daphnia with embryos, Diaphanosoma with embryos, and Eudiaptomus females without ovisacs. Nutrients were not serious constraints for plankton growth during the summer stagnation.

DAPHNIA DIEL VERTICAL MIGRATION AS A POSSIBLE SOURCE OF MIXING

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Biomixing refers to the contribution of living organisms towards the mixing of waters in oceans and lakes. Our project focuses the attention on the stirring generated by the vertical migration of zooplankton (DVM) in a quarry, mostly populated by Daphnia spp. The summer density stratification limits the vertical heat diffusivity to 10-7 m2/s. However, zooplankton by crossing the thermocline at sunset, may enhance the vertical diffusion of some orders of magnitude, improving the fluxes of dissolved substances.
Experimental measurements in an unstratified tank by Wilhelmus & Dabiri (2014) show that zooplankton can trigger fluid disturbances, such as jets or turbulent eddies, through collective motions. Leshansky & Pismen (2010) and Kunze (2011), model the eddy diffusivity and find to be 10-7 m2/s for small zooplankton. More realistic numeric simulations by Wand & Ardekani (2015) provides instead a diffusivity of 10−6 m2/s, supporting the idea of zooplankton-generated mixing.
Field experiments were conducted in Vobster Quay, a small and deep (40m) quarry with small wind fetch, located in the UK. Zooplankton vertical concentration was evaluated using a zooplankton net and a bottom-mounted ADCP was also employed to track the migration. Turbulence and mixing were measured with a microstructure temperature profiler. Our datasets, collected in late summer, do not show enhanced mixing in three different days. Furthermore, the analysis of temperature profiles does not show any turbulent patches that can be a source of mixing during the migration. The turbulent patches are either too small or too intermittent within the migrating layer.

TRAIT DYNAMICS IN PHYTOPLANKTON COMMUNITIES DURING OLIGOTROPHICATION – RESULTS FROM OVER 50 YEARS OF OBSERVATION

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Light and nutrients exhibit strong opposing vertical gradients in the pelagic water column, which underlie seasonal changes due to varying mixing intensity and nutrient uptake by algae. These gradients offer the possibility for the development of vertical trait separation in phytoplankton communities. Hence taxa with different trait-values are expected to show different distributions along the vertical gradient in the water column. In this study we analyzed how abiotic factors determine the vertical, seasonal and inter-annual distribution of algal communities and their functional traits. We used a vertically-resolved dataset with over 50 years of observation from Germany´s largest drinking water reservoir, which underwent a strong shift from eutrophic to oligotrophic conditions in the nineties. We found that the development of vertical niches is high during periods with high thermal stratification and low vertical mixing. Therefore the highest vertical separation of different phytoplankton taxa and traits occurs during stratification in summer. We show that seasonal and vertical succession of phytoplankton traits differed between eutrophic and oligotrophic years. Moreover we will test the hypothesis that algae with high nutrient competition abilities are more dominant at the surface, while algae dominating in deeper water layers are good light competitors.

GROWTH AND SURVIVAL OF JUVENILE FRESHWATER PEARL MUSSELS IN THE VLTAVA RIVER

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The aim of this study was to determine habitat suitability for juvenile freshwater pearl mussel development in Vltava River basin (Sumava National Park, Czech Republic). Bioindication experiments based on in situ exposition were performed. Both standard Buddensiek mesh cages with individual containment and sandy cages with at least 100 juveniles were used. Growth rate and survival rate were tested using juveniles of 1+ years of age. In two seasons 2014 and 2015, ten localities were evaluated including one comparative locality in neighboring Blanice River. Suitable conditions for juvenile mussel development were confirmed at several localities, as well as some unsuitable sites. A survival rate of the juveniles ranged from 0% to 100% depending on a locality position. A growth rate reached up to 153 % per 3 months exposition in the best locality. The influence of locality position within the longitudinal river profile was detected and each bioindication method gave somewhat different results. In the sandy cages, the growth rate was maximal in the middle stretch of the river. On the other hand, the growth rate increased continually downstream if evaluated by the mesh cages method which eliminates some negative environmental factors.

THE EFFECT OF THERMOPEAKING ON THE DEVELOPMENT AND COMPOSITION OF PERIPHYTON

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Periphyton plays a major role in lotic ecosystems and is often affected by multiple stressors. Thermopeaking (TP) combines stress of sudden flow velocity increase and abrupt water temperature alteration. The aim of this study was to provide knowledge about the impact of TP on periphyton, considering as well successional and habitat aspects. An experiment was conducted for 52 days in Lunz am See (Austria) in an experimental flume setting. The major investigated algal parameters were biomass, algal pigment distribution and phosphatase activity. Periphyton was exposed to two treatments (cold TP and warm TP, ± appr. 10°C) and no treatment (control), whereas TP was performed daily for one hour. Additionally, flumes were subdivided into pool and riffle sections and habitat specific effects were investigated. The findings showed that TP had an effect on periphyton, foremost only when treatment time and habitat effects were included: After 52 days of treatment periphyton exposed to warm TP showed lower biomass, while cold TP enhanced phosphatase activity. Furthermore, in pools algal community composition after 52 days was altered (cold TP increase of diatoms, control increase of chlorophytes). Also, in pools and riffles algal biomass was triggered by TP. The main conclusion was that TP altered community composition which in turn impacted other investigated parameters. Restoration projects should address effects of hydropower plant operation by considering the seasonal development of algae, local habitat conditions and environmental flow approaches.

FOOD AVAILABILITY AND ITS EXPLOITATION IN HIGH ARCTIC STREAMS

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The high arctic is defined by harsh climate, with cold long winters and short summer periods. This has various effects on the streams and the biota, which live close to their distributional limits. This also counts for chironomids, among the most abundant benthic families in Svalbard rivers. The main objective of our study in summer 2016 in seven river sites around Kongsfjorden, Svalbard, was to define available food and its exploitation by benthic invertebrates. Qualitative and quantitative sampling resulted in the abundance of the benthic assemblage as well as numerous individuals for succeeding qualitative and quantitative gut content and stable isotope (N, C) analyses of the major taxa. Along the gradient of harshness we found significant differences in the benthic fauna, food sources and exploitation. Surprisingly, in this high level of harshness quite a variety of taxa and feeding modes were found.

PERSPECTIVES OF COHERENT ANTI-STOKES RAMAN SPECTROSCOPY (CARS) FOR ASSESSING FATTY ACID CONTENT OF MICROSCOPIC BIOLOGICAL SAMPLES

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Measuring fatty acid (FA) content of benthic micro-invertebrates using mass spectrometry is challenging because of the need to accumulate signal from many individuals to detect a relevant signal. This chiefly precludes species-specific or intra-cellular investigations of FA distribution.

Raman scattering is based on inelastic scattering of light by molecular bonds, each of which has a characteristic vibrational energy. By collecting all photons which are spontaneously scattered by molecular bonds in a sample, a spectrum of the distribution of bonds, i.e. its chemical composition, can be assessed. In rare cases, by receiving energy from a molecular bond in an excited vibrational state, the scattered photon is blue-shifted (anti-Stokes Raman scattering). This process can be amplified by coherently exciting (and detecting) all photons in a process called coherent anti-Stokes Raman scattering, which also enables imaging the distribution of these molecular bonds. CARS can detect the 2845 cm-1 CH2 vibration (in aliphatic chains), which functions as a general FA biomarker and provides a detailed 3D picture of FA distribution in microscopic samples. CARS is non-destructive, chemically selective and sample preparations and optical measures are quick and relatively inexpensive.

Here we used CARS microscopy to visualize FA distribution in free-living nematodes. Effects of copper exposure on FA distribution in worms' bodies were exemplified. Significant fat storage was only found for adult nematodes, and exposure to copper reduced the number and size of FA droplets. CARS microscopy has the potential to reveal patterns of lipid metabolism in microscopic benthic organisms at an unprecedented resolution.

COMMUNITY STRUCTURE AND LIFE STRATEGIES OF MACROZOOBENTHOSIN KARST SPRINGS OF WESTERN CARPATHIANS - INTRODUCTION OF THE PROJECT

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Karst springs represent a unique ecosystem with relatively stable thermal regime influencing both structure and life history strategies of many aquatic invertebrates. Thanks to such stable conditions springs are generally thought to be ecological laboratories. In addition, natural springs are considered to be rare habitats due to their capturing as a source of drinking water. Our ongoing project deals with more than eighty karst springs within Slovakia. One of the main objectives of the research is to identify the macrozoobenthos assemblages' structures of karst springs and to analyze the influence of different ecological factors affecting these assemblages at local and regional scale. At individual and population level the project is focused on the analysis of factors governing life cycles, population characteristics, as well as the secondary production estimates of dominant taxa in springs with different thermal and hydrological regime. It appears that constant temperature enables aquatic organisms to perform asynchronous life cycles with overlapping cohorts which makes the CPI estimation very difficult. Conducting in situ experiment we will try to verify the accuracy of already published values of the CPI of selected species in constant temperature springs and to find factors responsible for the differences in the secondary production estimates in different types of streams. Last but not least, we need to define the most valuable springs from the nature conservation point of view and possible threats affecting them.

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HOW DO STREAM INVERTEBRATES DEPEND ON BASAL RESOURCES ALONG A LONGITUDINAL PRE-ALPINE STREAM GRADIENT?

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While many streams and rivers are dominated by terrestrial inputs of organic carbon, algae form a very important part of the trophic base for stream food webs. In part, this is because of their higher polyunsaturated fatty acids (PUFA) that are essential for invertebrate growth and reproduction. However, it is still poorly understood how stream invertebrates rely on the PUFA compositions of basal resources along a river longitudinal gradient from headwaters to downstream sites. We conducted a field study in a pre-alpine river network, Austria, to examine how invertebrates adjust to variations in dietary PUFA. Benthic algae, leaf litter and invertebrates were collected along a river longitudinal gradient, and their fatty acid compositions were analyzed. Our results showed that benthic algae were exclusively abundant in long-chain PUFA compared with leaf litter regardless of sampling sites, whereas leaf litter only contained short-chain PUFA. Algae from headwaters contained more long-chain PUFA than that from downstream sites, whereas algae from downstream sites contained more short-chain PUFA. Stream invertebrates were more enriched in long-chain PUFA compared with algae, and their PUFA composition varied with algal PUFA, indicating their limited ability to regulate their own PUFA content. Furthermore, the long-chain PUFA content in predatory invertebrates was higher compared with herbivores and detritivores. Our study suggests that algae are the more nutritional food source for stream invertebrates rather than terrestrial leaf litter along a river longitudinal gradient. Our findings present the first "PUFA map" along a river continuum and will provide great predictive power for future species conservation and stream restoration.

SHORT TERM VARIATIONS OF DISCHARGE AFFECT COMMUNITY STRUCTURE OF BENTHIC MACROINVERTEBRATES IN A LOWLAND REGULATED RIVER

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Benthic macroinvertebrate responses to flow were studied in the regulated Oglio River, outflowing from Lake Iseo (Central Prealps, Northern Italy). Macroinvertebrate samplings were performed 6 times at 4 sites from April to September 2014 and 2015. Taxa were sorted and identified at the family level. The main goal was to assess the relationship between discharge and family richness, density and the occurrence of sensitive taxa. The effects of current velocity and water depth were also studied. The sites were located downstream of four dams in a 30 km river stretch. In each site 10 replicates samples were performed with a Surber net with a 0.05 m2 area. At the same time, the main physical and chemical variables were also measured. Data were analyzed in a linear mixed effect framework to take into account the random variation due to site and sampling date. The organism density, ASPT index and EPT richness were negatively affected by discharge and flow variability. A negative relationship between family richness and density with depth was found; while EPT richness and ASPT were related to neither velocity nor depth. Even in a short river stretch, macroinvertebrates communities responded differently to hydrological factors and local conditions, e.g. water depth due to riverbed erosion, increased current velocity, lack of connectivity with the floodplain. These results are discussed for their relevance in both monitoring and management of regulated rivers.

PRODUCTION OF MEIOFAUNA IN FRESHWATER ECOSYSTEMS

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The distribution of biomass production and its allocation across populations under environmental constraints draw a picture of community dynamics and energy flows in ecosystems. However, ubiquitous communities like microscopic benthic invertebrates (meiofauna) are still seldom included in freshwater production budgets. In a case-study, we monitored the meiofauna dwelling in the sediment at two headwater stream sites during one-year. The two streams were similar in their granulometries and temperature regimes, but they differed in their flow velocities and nutrient balances, which allowed investigations of the effects of these factors on the density and production of different taxonomic groups of meiofauna. Meiofaunal production in the top sediment was among the highest reported so far for a streambed. Allocation of density and production across taxonomic groups differed between the two streams. Tardigrades, rotifers, oligochaetes, and gastrotrichs thrived in phosphate-rich, slow-flowing waters, whereas nematodes, micro-turbellarians, and harpacticoid copepods were better adapted to nitrate-rich, fast-flowing waters. Body-size distribution was mostly multi-modal, with important contributions of minute individuals weighing between 0.01 and 0.1 µgC. Throughout further comparison with other datasets we highlight that, despite their small size, microscopic invertebrates can produce substantial amounts of biomass due to pretty high P/B ratio, and thus deserves inclusion in benthic production budgets.

THE EFFECT OF SOME ECOLOGICAL FACTORS ON FATTY ACID CONTENT OF BENTHIC INVERTEBRATE GAMMARUS LACUSTRIS, VALUABLE FOOD SOURCE FOR FISH

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Aquatic invertebrates are valuable sources of essential polyunsaturated fatty acids (PUFAs), namely, eicosapentaenoic acid (EPA, 20:5n-3) and docosahexaenoic acid (DHA, 22:6n-3) for fish. Phylogeny, diet and various ecological factors affect fatty acid (FA) composition of aquatic invertebrates. A contribution of these factors to FA profiles of invertebrates is still unclear. We focused our study on the effect of ecological factors. To avoid the effect of phylogeny, which strongly influences FA composition of animals, we studied several populations of one cosmopolite benthic species, Gammarus lacustris, inhabiting lakes differing in temperature, salinity, and the presence of fish. We found that differences in FA percentages of G. lacustris were mainly affected by differences in their diets. Some populations preferred dinoflagellates, cryptophytes, green algae/cyanobacteria and bacteria, other populations selected diatoms, and some other populations consumed zooplankton. The effects of water temperature and salinity on FA percentages of G. lacustris were not revealed. However all factors studied affected the contents of EPA and DHA in G. lacustris. Populations from cold, saline, and fishless lakes had significantly higher contents of EPA and DHA. We suppose that climate warming, desalination of waters and stocking of lakes with fish may lead to a decrease in food quality of an important food source for fish, gammarids.

THE INTERACTIVE EFFECTS OF FLOW AND NITRATE SUPPLY ON TOXIC BENTHIC CYANOBACTERIA: A STREAMSIDE CHANNEL EXPERIMENT

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Toxic benthic cyanobacterial proliferations, particularly of the genus Phormidium, are an escalating problem in freshwater environments worldwide. These have been associated with animal toxicosis events and may affect the health of aquatic organisms. Phormidium proliferations are problematic in New Zealand rivers, where there has been a marked increase in the distribution, intensity and frequency of proliferations in recent decades. Observational studies have indicated a range of environmental factors as potentially important in determining patterns of Phormidium occurrence. However, manipulative experimental approaches are required to disentangle and identify the causal mechanisms underlying these patterns. Phormidium is common in rivers draining agricultural catchments, and elucidating the individual and synergistic effects of nitrate concentration and flow velocity on bloom development, are an important consideration for both fluvial science and management. We conducted a streamside channel experiment that evaluated the responses of Phormidium-dominated mats in terms of biomass (chlorophyll a and phycoerythrin), patch expansion, cellular nutrient concentrations and taxonomic composition to three different nitrate concentrations, crossed with two flow levels, resulting in a total of six treatments each replicated three times. There was no significant difference in the patch expansion rates across the six treatments. Phormidium biomass accrual was significantly higher under fast flow treatments compared to slow flow treatments. Nitrate, had no effect on Phormidium biomass accrual. The study highlights the complex and interactive relationships between flow and nitrate and benthic Phormidium accrual cycles.

MORE THAN JUST ENERGY – LIPID STORAGE IN MAYFLIES

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Insect larvae accumulate lipids presumably to store energy. Due to their high energy content lipids are the most efficient energy-storing compound for most organisms. However, storing energy might not necessarily be the only function of the accumulated lipids. This was indicated by the analysis of fatty acid (FA) composition of mayfly nymphs (late instars) using an adapted Bligh & Dyer extraction, followed by a fractionation of the total lipid extract in neutral lipids, glycolipids, and phospholipids in addition to a subsequent derivatization of the fractions for GC-MS measurement.

As expected, neutral lipids representing mostly storage lipids, made up >90% of the total lipids. Quite unexpectedly however, neutral lipids contained high amounts of polyunsaturated fatty acids (PUFA, 24-50%). The largest percentage of PUFA was composed of ALA (α-linolenic acid, 18:3ω3) and EPA (eicosapentaenoic acid, 20:5ω3) as well as small amounts of LIN (linoleic acid, 18:2ω6) and ARA (arachidonic acid, 20:4ω6). ALA and LIN are essential fatty acids which can be desaturated and elongated to EPA and DHA. However, this process is physiologically costly and its efficiency varies considerably among tissues, organisms and developmental stages, so that the dietary intake of EPA and DHA is generally preferred.

The accumulation of these valuable PUFA in the lipid storage indicate that the lipids stored are not a sole source of energy but also of essential FAs necessary e.g. for reproduction. These results illustrate that emergence of aquatic insects might represent a substantial export of essential FAs from aquatic to terrestrial ecosystems.

WHEN THE GOING GETS TOUGH, THE TOUGHS GET GOING

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Glacier retreat provides striking evidence of environmental change in alpine environments, leading to significant changes in physico-chemical characteristics and biological communities in glacier-fed rivers. Aquatic larvae of the Chironomidae, or nonbiting midges, are the first invertebrates colonizing alpine headwaters, and the first consumers in these harsh environments. Species composition in the two subfamilies, Diamesinae and Orthocladiinae, is diverse and strongly affected by changing habitat- conditions upon glacier retreat. The overall effects of the environment on chironomid community structure are largely understood, but its influence on functional strategies such as feeding habits of same species are not. Here we show that Diamesinae have extremely flexible feeding strategies that explain their abundance, high body-mass, and predominance in glacier-fed streams. Along a multifactorial ecological gradient from benign to harsh, Diamesinae expanded their isotopic niche area and covered more trophic levels when conditions harshened. In contrast, niche areas of Orthocladiinae remained small and were unrelated to water temperature, sediment transport and degree of glacial influence. In Diamesinae mean body-mass increased with harsher environmental conditions, but no such effects were found in Orthocladiinae. As facultative predators and able to feed on diverse food sources, the Diamesinae have evolved survival mechanisms that allow them to thrive and successfully reproduce in glacier-fed streams, which likely explains their predominance in these habitats. Climate change-induced glacier retreat affects global water balance, with many downstream effects, including on irrigation and domestic use, and our study deepens our understanding of its effects on animals living in or even depending on glacier-melt.

THE ECOLOGICAL IMPACTS OF CATTLE ACCESS ON FRESHWATER ECOSYSTEMS

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Pollution related to agriculture poses a serious threat to freshwater ecosystems and drinking water quality. In Ireland, agricultural activities make up 65% of total land use with cattle related activities dominating the landscape. Where cattle have access to freshwater bodies, water quality deterioration via stream bank degradation, habitat homogenisation and nutrient enrichment can occur. Empirical evidence is largely of US and Australasian origin although research in the context of Western Europe is growing. In Ireland, seasonal effects of cattle access on high order, lowland rivers have been detected. However, little evidence exists in relation to low order streams. These small streams form 77% of the river network in Ireland and are highly vulnerable to pollution impacts due to their high connectivity with agricultural land and low dilution capacity. In 2016 a national, multi-institute study on the potential impacts of cattle access on stream water quality was initiated. It also involves an assessment of the environmental, ecological and socio-economic impact of existing and potential measures that prevent cattle access to watercourses. This paper reports on a component of this study which has assessed the potential impacts of cattle access on first and second order streams through investigations of macroinvertebrate and floral communities as well as the levels of sedimentation upstream and downstream of the access points. Macroinvertebrate communities have been sampled in spring and autumn. Analysis of the spring data has revealed statistically significant impacts at certain cattle access points largely due to reductions in abundances of certain ephemeropteran species and increases in sediment tolerant Oligochaeta and Chironomidae. Significant increases in deposited sediment mass were also recorded at a number of cattle access points during the autumn sampling season.

CADDISFLY DISTRIBUTION IN A TROPICAL STREAM

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Trichoptera (caddisflies) are important components of the pollution-sensitive invertebrate taxa that are commonly used for assessing water quality worldwide. Their natural distribution is thus modified by anthropogenic factors, notably oxygen demand, related to the presence of organic matter and other oxidising substances, and to suspended sediment. The natural factors that influence caddis distribution mean that a correct interpretation of the presence/absence of a particular taxon requires an in-depth understanding of taxon-habitat relationships. Such knowledge exists in temperate regions (notably in Europe and in North America) after decades of research, but it is almost non-existent for tropical streams.

Trichoptera occupy a number of important ecological roles within stream trophic chains and have representatives in all functional feeding groups. In particular, some caddis taxa are effective shredders found in streams worldwide. This is the also case in tropical streams, in which shredders are considered to be under-represented.

We present an analysis of the distribution of Trichoptera collected in a single Afro-tropical stream in Kenya. A detailed description of the in-stream biotopes from which samples were collected is linked to partition of the taxa into functional feeding groups, established through the assessment of ΔN and ΔC stable isotopes in degutted caddis larvae. We link this to analysis of the composition of larval gut contents, and to a morphological assessment of the shape and adaptation of their mandibles.

Our results contribute to understanding the ecological role of poorly known caddis taxa and provide greater insight about the presence of shredders in tropical streams.

WATER SOURCE RATHER THAN BASAL RESOURCE VARIABILITY DRIVES FOOD WEB PATTERNS IN ALPINE STREAMS

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Basal resources in stream ecosystems originate either from autochthonous (i.e., within-system) or allochthonous (i.e., external) production. The abundance and relative proportion of the basal resources likely determine food web composition, structure, and production. Allochthonous resources generally increase downstream, especially in the high elevation catchment area. Additionally, water sources (e.g., snow/glacial melt) affect the delivery of allochthonous inputs as well as environmental conditions (e.g., flow, temperature) and thus autochthonous production. We studied three catchments with differing degrees of glacial runoff and vegetation cover (alpine prairie to subalpine forest; up-to-downstream). Sites were sampled approximately monthly for biofilm, benthic organic matter, macroinvertebrates and surveyed for environmental conditions (temperature, depth/discharge) using sensors. Biofilm chlorophyll-a (chla) was highest in the snowmelt-fed stream and only showed an up-to-downstream increasing pattern in September during the chla-peak (6.13 to 34.19 mg/m2). The two streams with glacial influence had generally low chla (<15 mg/m2) until the stable flows in December. Coarse benthic organic matter (CBOM) was also higher in the snowmelt-dominated streams compared to the glacial-fed streams (mean 7 vs 3 g/m2). In summer (Jul-Sep), CBOM peaked in different months for the different catchments and no downstream patterns were evident. Macroinvertebrate densities were low in July and August in the glacial melt influenced streams while the snowmelt dominated streams showed high densities of very small stoneflies in those months. Results suggest that water source and expected effects on flow and temperature drive patterns in food webs rather than upstream to downstream difference in basal resources.

TEMPORAL AND LONGITUDINAL VARIATION OF BENTHIC MACROINVERTEBRATE ASSEMBLAGES IN A FRAMEWORK OF NATURAL AND ANTHROPOGENIC DISRUPTIONS

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Along an entire melting season, our study examined the benthic macroinvertebrate assemblage of the Saldur stream, a glacier-fed stream in the Italian Central Eastern Alps, assessing its interactions with the abiotic environment and analysing the effects of the spatial and temporal components on a set of faunal parameters. Surber samplings on a monthly basis of the benthic community was carried out, as well as collection of data concerning suspended solids, conductivity, discharge, channel stability, distance and influence of the glacier. UPGMA clustering based on fusion levels revealed both site position and time of sampling to be key factors for the faunal assemblage, despite coefficient of variability managed to disentangle the two components, identifying the prominent effect of site position. Moreover, using the Multivariate Regression Trees (MRT) statistical technique, reinforced by CCA, a model defining the patterns of the macrobenthic invertebrate community as a function of the abiotic factors was built. Main drivers of the benthic macroinvertebrate assemblage were identified to be discharge, channel stability, conductivity and distance from the glacier snout. The analysis carried out represented a starting point for the monitoring of the site in the framework of natural (i.e. climate change) and anthropogenic (i.e. hydroelectric power production) disruptions of the current environmental features, both representing an issue for the examined stream.

UNEXPECTED SPATIO-TEMPORAL PATTERNS OF LARVAL SIZE IN A HIGHLY GLACIATED RIVER

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Glacially influenced alpine streams are fascinating and unique habitats, being characterized by year round harsh environmental conditions. Only few highly adapted benthic insect species, mainly from the chironomid order Diamesina, are able to live in these extreme conditions. Several research papers have shown effects on ecosystem structure and function, however, cause-effect relationships of abiotic key components on aquatic insects' life strategies are still barely known. Here we report on the development of alpine key chironomid taxa in a highly glaciated stream, where we use biometrical analyses to elucidate spatio-temporal patterns in larval size, biomass and biovolume. Sampling took place at Schlatenbach, a river draining the Schlatenkees, which is the largest glacier in the mountain range Venediger Gruppe (Hohe Tauern National Park) at three sites in close proximity to the draining glacier at six occasions from August to October 2015. Quantitatively sampled larvae were biometrically analyzed and showed differences in larval size, biomass and biovolume among taxa and in most taxa higher values close to the glacier. Considering the non-significant differences in temperature, turbidity and other abiotic parameters among sites but the significantly higher organic matter and chlorophyll concentrations close to the glacier, suggests that nutrient and food availability plays a crucial role. Presumed harsh conditions in these environments may exclude many taxa however favor others when their essential needs are guaranteed.

PERIPHYTIC ALGAE SUBSTRATE SPECIFICITY: OVERALL DIVERSITY OR SPECIFIC TAXA ABUNDANCE?

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Artificial substrates have been described as a promising tool in periphyton studies, but the substrate specificity of periphytic algae is still debated question. Periphyton samples were collected from artificial substrates (glass, ceramic, willow and yew tiles). Artificial substrates were deployed in Sava Lake (Belgrade) in July 2014, and samples were collected weekly until September 2014 (8 weeks). We evaluated diversity and abundance of algae in developed biofilm. When the periphytic community was taxonomically analyzed, 87 algal taxa were recorded in total, 22 of Cyanobacteria, 45 of Chlorophyta, 1 of Chrysophyta, 16 of Bacillariophyta and 3 of Dinophyta. On glass and willow tiles 69 taxa were recorded, on ceramic 66 and on yew 63, and when presence of taxa was concerned ceramic and glass formed one group, while yew and willow differed. The most abundant taxa overall was Mougeotia sp. and Pseudanabaena papillaterminata. Mougeotia sp. was clearly dominant in periphytic communities developed on glass, ceramic and yew tiles while Pseudanabaena papillaterminata followed as subdominant, but in the community developed on willow tiles these taxa switched the roles e.g. Pseudanabaena papillaterminata was the most abundant taxa. Our results suggest that filamentous Pseudanabaena papillaterminata has preference for willow substrate over the others used in this study. This occurrence could be addressed to the willow tiles biodegradation products that possibly promote this Cyanobacteria proliferation. Although our study showed slight differences in taxonomic composition, abundance of specific taxa could be more substrate specific attribute of algal periphytic community.

SPECIES-SPECIFIC PREFERENCE OF BENTHIC MACROINVERTEBRATES FOR FOOD SOURCES VARYING IN PUFA CONTENT

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Chemical composition of organic matter (OM) is a key driver for the degradation of detritus by detritivorous organisms, but this is often overlooked in studies aiming to link biodiversity and ecosystem functioning. Polyunsaturated fatty-acid (PUFA) content has been proposed as candidate indicator of food origin (plant or animal), food quality and palatability. However, whether benthic invertebrates developed preference for specific food-sources based on PUFA content remains uncertain. A key question is thus whether macroinvertebrates can select quality and origin of food sources based on PUFA content. Therefore we tested the influence of the PUFAs linoleic acid (plant) and arachidonic acid (animal origin) on food choice and OM consumption by aquatic macroinvertebrates using standardized surrogate substrates (decomposition and consumption tablet, DECOTAB). In microcosms, we observed differences in food preference of six invertebrate taxa. Three species chose food sources containing linoleic acid over cellulose only food sources, showing a clear preference for plant derived PUFAs. We also observed a preference against food sources containing arachidonic acid for three species. This effect appeared to be overruled in the field due to unknown sources of natural variation. Although we observed differences in consumption in ditches related to species richness, consumption rates were comparable for all three types of DECOTAB deployed. From our study we concluded that (detritivorous) macroinvertebrates have species specific food preferences. This study thus indicates that complex interplay between PUFA content of natural OM sources and invertebrate resource niches is ultimately driving the performance of benthic macroinvertebrates and functioning of aquatic ecosystems.

RECENT RECOVERY OF ACID DAMAGED MACROINVERTEBRATE ASSEMBLAGES IN THE BOHEMIAN FOREST LAKES

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Acidification of the Bohemian Forest lakes caused by sulphate and nitrate deposition between the 1950s and 1980s strongly affected benthic and pelagic assemblages of macroinvertebrates. Lake water acidification peaked in the mid-1980s and, along with substantial decrease in acid deposition, has been reversing since then. Chemical recovery of lakes exhibits typical changes in water chemistry, such as a decrease in concentrations of strong acid anions, base cations and aluminium, followed by an increase in pH, acid neutralising capacity and concentration of dissolved organic carbon. However, continuing adverse effects of aluminium delayed the biological recovery for at least a decade and recent assemblages still suffer from acid stress. First signs of biological recovery included colonisation by vagile species, reappearance of some indigenous or acid-sensitive species and decline in abundances of eurytopic acid-tolerant species. This study focuses on eight natural lakes of glacial origin on the Czech side (5) and the German side (3) of the Bohemian Forest. We compare biological recovery of two types of lakes – four partly recovered low-aluminium lakes and four acidic high-aluminium lakes. The main aim is to explore compositional changes of macroinvertebrate assemblages in response to recent changes in lake water chemistry between 2010 and 2015. We also compare recent species richness of aquatic insects to that observed in 1999–2007.

TOP-DOWN AND BOTTOM-UP TROPHIC INTERACTIONS IN LAKES, AS EVALUATEDY THE SIZE-DENSITY RELATIONSHIPS OF FISH COMMUNITIES

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Trophic cascades induced by differing abundances and sizes of planktivorous and omnivorous fish can modify phytoplankton biomass among lakes with similar nutrient concentrations. In turn, fish abundance and size in lakes may reflect the local nutrient supply. We compare the intensity of trophic cascades (top-down effect) and the effect of nutrient supply (bottom-up effect) in freshwater food webs from fish to phytoplankton as based on size-density relationships within the fish communities while accounting for a substantial variation in environmental gradients between the lakes. Our hypothesis is that size-density relationships of fish are a sensible metric to evaluate the intensity of food web interactions. We explored body-size structure of fish communities in 75 lakes from five European ecoregions. We tested for the response of linear abundance size spectrum (linear ASS) and Pareto II to chlorophyll a (chla) concentration (bottom-up) and chla:total phosphorus (TP) ratio (top-down). We included local temperature and lake morphometry as covariates. There were highly significant negative relationships between the parameters of the linear ASS or the Pareto II distributions and chla, indicating a reduction in size of fish in more productive lakes (bottom-up control). In contrast, the effects of fish size distributions on the chla:TP ratio were weaker and in opposing direction between the parameters of linear ASS and Pareto II distributions. These results suggest that phytoplankton biomass is a good predictor of fish size distribution in lakes, whereas the variable fish sizes observed across the lakes were only a poor predictor of the intensity of trophic cascades.

INFLUENCE OF AGRICULTURAL LAND-USE ON AQUATIC-TERRESTRIAL PREDATOR-PREY RELATIONSHIPS IN ROMANIA

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Streams and their riparian zones are linked via fluxes of material and organisms. The aquatic-terrestrial linkages can be affected by land use. For example, stressors associated with agriculture such as pesticides and nutrients can differentially alter arthropod communities in water and on land. This may result in complex response patterns of terrestrial predators relying on aquatic prey. Whereas the different stressors are often closely correlated in landscapes with intensive agriculture, traditional low intensity agriculture still prevails in rural regions of Central and Eastern Europe such as Romania. We examined the response of aquatic-terrestrial predator-prey relationships in the surrounding of Cluj, Romania to a gradient of agricultural intensity.

In total 16 streams where investigated for hydromorphological quality, nutrient and pesticide concentrations to study how the diet of terrestrial predators such as riparian spiders is influenced by these factors.

We compared the contribution of aquatic prey to the diet of the riparian spiders Tetragnatha sp. and Pardosa sp. using stable isotope analyses. We found complex response patterns along the gradients, which are discussed in our presentation.

HABITAT COMPLEXITY AND PREDATION RISK MODIFY TROPHIC INTERACTIONS AND ENERGETIC EFFICIENCY OF INTERMEDIATE PREDATORS

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Feeding and metabolic rates are of paramount importance for community dynamics, energy flows in ecosystems and functional consequences of biodiversity loss. However, little information exists about how multiple abiotic and biotic factors jointly influence the strengths of predator-prey interactions and metabolic rates of intermediate predators. To fill this gap, we performed a laboratory experiment to investigate the effects of habitat complexity, prey density and predation risk by large dragonfly larvae (Aeshna cyanea) on short-term interaction strengths (i.e., feeding rate) of the larvae of three odonate species (Sympetrum sanguineum, Libellula quadrimaculata, Ischnura cf. elegans) preying on cladocerans. We found that, for all predator species, interaction strength decreased with prey density. Predation risk significantly decreased interaction strength for S. sanguineum whereas it had no effect on the feeding rates of the other two predators. Finally, vegetation significantly increased interaction strengths but only in predation risk free treatment. We also investigated the impact of predation risk (i.e., chemical cues from Aeshna larvae) on the metabolic rates of the larvae of the three intermediate predators. Metabolic rate varied among predator species but was not affect by predation risk. In conclusion, we showed that the effects of vegetation and predation risk on intermediate predators are context-dependent and interactive. Our study thus suggests that multiple factors must be considered in order to understand and predict environmentally driven variations in trophic interaction strength and metabolic rates that underlie the energetic efficiency of individual consumers.

ARE DIVING BEETLES LARKS OR OWLS? FIRST INSIGHTS INTO THE DIURNAL ACTIVITY PATTERNS OF CYBISTER LATERALIMARGINALIS

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The accuracy of field studies of aquatic macroinvertebrate communities depends on our ability to reliably estimate their population sizes and distribution in space. However, we know little about the movement and activity patterns of many benthic macroinvertebrates, which critically underlie this endeavour. This is particularly true for diving beetles from the Dytiscinae subfamily. To fill this gap, we studied the movement and activity patterns of Cybister lateralimarginalis in a laboratory experiment focusing on their behavioural responses to baited fishing traps, which are now routinely used for the monitoring of large and mobile species of predatory aquatic insects. Observations were performed in 2.4 m x 2.4 m square basins. We recorded beetle behaviour continuously with IR-sensitive cameras for 8 hours during the day and night conditions and subsequently scored the videos for key behavioural patterns. We observed highly contrasting behaviour between day and night: the movements were more random during day and more regular at night. Moreover, the individuals spent more time swimming at night than during the day and the periods of air uptake were longer during the night, probably reflecting increased metabolic demands associated with higher activity levels at night. The research was supported by the ÚNKP-16-3-IV New National Excellence Program of the Ministry of Human Capacities. The conference participation was supported by the Doctoral Student Association of University of Pécs.

UNEXPECTED NONLINEAR EFFECT OF HABITAT COMPLEXITY GRADIENT ON FUNCTIONAL RESPONSES

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Species interaction strengths that underlie the structure and stability of food webs can be modified by multiple environmental factors. Habitat complexity features prominently among abiotic factors that modify the strengths of consumer-resource interactions. Previous studies showed that increased complexity can either weaken or strengthen feeding links by providing refuges for the prey or perching sites for the predator and by limiting the visual range and movement of either predator or the prey. All these mechanisms can influence the shape and magnitude of the consumers' functional responses. Surprisingly, virtually nothing is known about possible shapes of functional responses along a gradient of habitat complexity. We carried out a laboratory experiment to estimate the functional response parameters along a gradient of complexity ranging from an entirely unstructured to highly structured habitat. As a case study, we used dragonfly larvae feeding on insect prey. Surprisingly, our results revealed no refuge effect of habitat complexity that would lead to a change in the shape of the functional response and we found limited support complexity-dependent attack rates. Instead, the most parsimonious model was characterized by constant attack rates and unimodal dependence of handling time with a maximum at intermediate level of habitat complexity. Our results show that future studies of habitat complexity studies should carefully characterize habitat complexity beyond the binary scale of presence/absence.

PREDATION, COMPETITION, CHEMICAL STRESSORS IN FRESHWATER BIOFILM: SYNERGISM OR ANTAGONISM?

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European Union represents 45% of world's pesticide tonnage. Just a little part of pesticides really hit their target organisms; the remaining reaches the environment by several phenomena as leaching, ending up in aquatic ecosystems: the final receptors of microcontaminants. Chemicals stressors induce taxonomic changes on fauna and flora, which are now the focus of many biomonitoring studies. However, water quality indices only take one biological compartment into account, and put combination of abiotic and biotic factors aside. We tested separately four factors (predation, competition, diuron and imidaclopride) on two diatom species exhibiting distinct morphotypes: Planothidium lanceolatum and Gomphonema gracile (normal and teratogen forms), to quantify daily their growth kinetics under varied pressures. The predator used was a nematod from freshwater Aquitaine biofilms: Aphelenchoides bicaudatus. We reproduced experiments combining the factors, to determine if they acted synergistically or antagonistically. P. lanceolatum is strongly impacted by interalgal competition. Nevertheless, under herbicide treatment, A. bicaudatus enhanced its growth thanks to medium enrichment with nutrients (feces, mucus trail agglutinating), and acted negatively on Gomphonema gracile, by grazing it. On the contrary, exposure to imidaclopride improved microalgal defence mechanisms, by forming associations, making them less accessible. Ecological relationships in freshwater biofilms (competition, predation) have non negligible effect on community composition, population behavior and impacts usually observed without considering these factors. These results call for a new approach concerning bioassessment methods of water quality and fundamental studies to improve our understanding of ecosystems functioning, for restoration and environment protection.

PHYSIOLOGICAL RESPONSES OF FRESHWATER FISH TO MULTIPLE STRESSORS

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Aquatic organisms face multiple challenges in human-altered rivers such as contamination and temperature changes. This exposure to multiple stressors is likely to alter fish metabolism and immunity through energy depletion and immune perturbations. Such physiological changes could have dramatic effects on fish ability to face parasites. However, this question remains understudied, especially in natural populations exposed to high variations in human-driven perturbations. To tackle this question, we studied different populations of brown trout (Salmo trutta) and gudgeons (Gobio occitaniae) distributed along a perturbation gradient (temperature changes and water contamination) located in South of France. The first aim of this study was to compare the health status of each population according to their exposure to stressful conditions. The second aim was to test the sensitivity of different biomarkers to assess the health status and phenotypic plasticity of fish exposed to different conditions. We compared the body condition, innate immune ability, DNA damages (micronuclei), body injuries and levels of infection by internal and external parasites. Fish showed various levels of external lesions linked to parasitism, as well as a decreased immunity and increased DNA damages along the gradient of perturbations, with differences depending on the population of origin. This highlights the high interindividual variability of response to multiple stressors and the need to take into account parasites in the assessment of environmental perturbations in human-altered rivers.

EARLY INVESTIGATIONS INTO THE RELATIONSHIP OF THE PARASITIC STAGE OF MARGARITIFERA MARGARITIFERA AND ITS FISH HOST IN CULTURE.

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The life cycle of the critically endangered freshwater pearl mussel (Margaritifera margaritifera) involves a parasitic stage in the gills of suitable salmonid fish. During this period the larvae (or glochidia) increase by more than 4 times their initial size before dropping off into gravel beds.

Over the last two years, in our facility an unusually early larval excystment has been observed. This exposes the newly excysted juveniles to early winter temperatures, potentially reducing their survival rate.

Previous studies have demonstrated how glochidial growth and therefore drop off is stimulated by constant warmer temperatures, as well as reporting a significant variation in timing and length of the excystment periods. Further studies show that differences in numbers and growth rate of attached glochidia indicate strong fish host specificity at species and strain levels.

Our recent observations cannot be simply explained by degree days. Before any significance of temperature can be attributed the suitability of different individuals of the same host population has been investigated. All hosts from the same stock were encysted under the same conditions. Encysted fish were split into length categories, the total number of glochidia in each fish was counted and 30 glochidia measurements were taken from each fish systematically. Fish weight and length were noted for each individual.

The results presented here are a step towards an improved understanding of this host-parasite relationship. In our facility, fish condition is not negatively affecting glochidial development, essential for successful captive breeding and reintroduction

PLANKTIVOROUS FISH POSITIVELY SELECT DAPHNIA BEARING ADVANCED EMBRYOS

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Planktivorous fish are visually oriented predators with the preference for larger and conspicuous zooplankton prey. Hence, the larger cladoceran species such as Daphnia are one of the most preferred fish prey. Moreover, when preying on daphnids, fish focus on the conspicuous individuals like those with clutches or ephippia. Similarly, embryos in the latest developmental stages should be more visible than those in earlier stages because of developed black-pigmented eye. This assumption was experimentally tested in mesocosm experiment. Our results clearly confirmed that fish selectively forage on the daphnids with embryos in the latest developmental stages in the brood chamber than on those with earlier stages. The cladoceran assemblages exposed to fish predation were mostly composed of smaller-sized females with embryos in the early developmental stages. Hence, fish predation may significantly alter daphnids' reproduction in this way.

THE EFFECTS OF RUN-OF-RIVER HYDROELECTRIC POWER SCHEMES ON FISH AND INVERTEBRATE COMMUNITY COMPOSITION IN TEMPERATE STREAMS AND RIVERS

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Run-of-river (ROR) hydroelectric power schemes are often presumed to be less environmentally-damaging than large-scale storage schemes. However, there are currently only a limited number of peer-reviewed studies on their physical and ecological impact. This presentation will summarise the findings from a policy secondment, funded by the UK's Natural Environment Research Council and the Environment Agency of England, which investigated the impacts of ROR hydroelectric power schemes on fish and invertebrate communities in temperate streams and rivers, using Before-After, Control-Impact (BACI) study designs. The study made use of routine environmental surveillance data collected as part of long-term national and international monitoring programmes at systematically-selected ROR hydroelectric power schemes and systematically-selected paired control sites. Five metrics of invertebrate community composition and six area-normalised metrics of fish community composition were analysed using linear mixed effects models. The results are discussed with respect to impacts from other sources of power, and recommendations are made for best-practice study design for future freshwater community impact studies.

MANAGING MULTIPLE STRESS FOR MULTIPLE BENEFITS: FIRST OUTCOMES OF THE EU PROJECT MARS

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Water management requires solid understanding of how multiple stressors affect ecosystem state and services. By the end of 2017, the EU project MARS (Managing Aquatic ecosystems and water Resources under multiple Stress) will have concluded four years of in-depth research on this topic. MARS looked into multi-stressor responses from experimental water body to pan-European scale, developed tools for modeling and diagnosing multi-stressor effects and guided management of multiply stressed aquatic ecosystems. Our presentation summarizes the project's progress, and provides first outcomes and key messages.

CONSERVING FRESHWATER ECOSYSTEMS: PAST, PRESENT AND FUTURE

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This paper looks back over the last 30 years and reflects on the way that freshwater nature conservation has changed, particularly in the UK and Europe, and identifies some areas where further progress is needed. This period has seen significant evolution in the philosophy, perspectives and practice of conservation, with one of the major drivers the passage of national and international legislation. International agreements such as the Convention on Biological Diversity, and European Union statutes such as the Habitats Directive and the Water Framework Directive have led to a reassessment of priorities in catchment management. The conservation of freshwater habitats and species, while not yet as distinct a field of endeavour as its marine counterpart, has spread into new areas. Many of these trends are reflected in the publication history of Aquatic Conservation: Marine and Freshwater Ecosystems, a journal that began life 25 years ago. Environmental pressures that were scarcely discussed then, such as climate change and the spread of invasive species, have grown in significance. New tools and techniques – in fields such as remote sensing, genetics, and data analysis – have been developed and applied in conservation studies, and new approaches focused on managing freshwater ecosystems at the catchment scale are increasingly being adopted. Yet despite many advances, weaknesses still remain, especially in the relationship between freshwater science and conservation. Those involved in conservation must articulate better the science needed for effective conservation; conversely, scientists must cultivate a greater awareness of the relevance of their research to conservation.

INTEGRATING HYDROBIOLOGY AND LANDSCAPE ARCHITECTURE IN THE TOURISTIC DEVELOPMENT AND MANAGEMENT OF A THERMAL LAKE

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The importance of this study is nested in the unique water quality and in the complexity of the challenges. The increasing demand for thermal water generates a number of environmental issues, starting form the effects of abstraction, to emitting them into surface waters as waste water. In 2014, a comprehensive touristic project was started in Zalakaros (Hungary), with a construction of an 1,2 ha artificial lake – as a new attraction and a secondary use of water – filled up with a spa's used thermal water. The physical and chemical conditions make this standing water a unique lake, and special habitat (e.g. high conductivity, low productivity). To fit this new development into the landscape, protected plant relocation, aquatic and riparian machropyte planting, lake management – maintenance, nature interpretation had to be planned as well. To ensure a reasoned decision-making process, we analysed the terrestrial vegetation, sediment and water quality sampling processes had been performed, and the succession of machrophytes are systematically monitored.
In the third year, the results cover natural succession processes ("rise and fall" of specific macrophyte species in various years: Echinochloa crus-galli, Cladophora sp., Myriophyllum sp.), planted macrophyte survival rates, change tendencies of water chemistry, phytoplankton species composition (dominant species: Cladophora sp., Navicula sp., Nitzschia sp., picoalgae species), management strategies, as well. To maximize the ecosystem services in a dynamic, rapidly changing lake ecosystem, to balance between social demands and long-term sustainability, a cooperation of various experts and decision-makers is required, coupled with crucial timing of interventions and maintenance processes.

OPERATIONAL ASSESSMENT OF REGIME SHIFTS: APPLICATION TO THE LONG-TERM ECOLOGICAL TRAJECTORY OF A LAKE UNDER MULTIPLE FORCING

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Large, abrupt and persistent changes have been observed in various ecosystems, and many have been referred to as regime shifts despite any explicit consideration of underlying drivers and dynamics. However, alternative mechanisms, including combination of new drivers, high environmental stochasticity, or persistence of the principal driving force, can cause abrupt changes in ecosystem states and mimic hysteresis, in absence of any regime shift. It is yet crucial, because of their serious implications on management targets, to operationally assess the actual frequency and occurrence of true regime shifts. In such purposes, we focused on the paleo-ecological trajectory of Lake Varese, a deep, hyper-eutrophicated peri-alpine lake that experienced three transitions over the last century. We combined ordination methods, changepoint analysis and general additive models, to test whether, or not, these transitions were true regime shifts triggering hysteresis. Only one transition could be qualified, based on its dynamics and the underlying drivers, as a nutrient-driven regime shift. Despite low macrophyte coverage for this hollow lake, vegetation might have had a stabilizing effect in the first stages of eutrophication and the shift was preceded by an increase in autocorrelation and variance more than two decades before. Since then, the lake trajectory has been evolving around this disturbed attractor. The most recent transition, despite sudden, was driven by current warming to which pelagic habitats have been more sensitive than littoral ones. Instead of triggering a new regime shift, climate warming has driven the lake further from its safe operating space.

ASSESSMENT AND MITIGATION OF STORM RUNOFF LOADS FROM AN INFORMAL SETTLEMENT (SLUM)

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One of the biggest global health problems today is that posed by urban conditions, most significantly in developing countries where there is a proliferation of informal settlements due to rapid and continued migration from rural to urban areas. Within informal settlements, the lack of infrastructure including sanitation and sewage facilities can generate serious problems for public health and the environment. Overall, research is lacking on the influence of stormwater runoff within high population density catchments, particularly in developing countries. This research evaluates how anthropogenic and environmental factors influence stormwater runoff quality and quantity (as characterised by hydrologic, chemical, and microbial measurements) during storm events in Enkanini, one of the primary informal settlements near Cape Town, South Africa. Five sample sites were selected to establish a spatial overview of runoff effects: two stormwater sites, two rainwater tanks and one control site. Initial results indicate extremely high levels of pollutants within the two stormwater runoff sites. The indicator organisms detected within the water samples taken from runoff sites were significantly higher than the South African Department of Water and Sanitation guidelines with samples at least 600% higher than the recommended guidelines. Similarly for chemical results, the highest levels were detected in stormwater runoff sites. Based on initial results, there appears to be an indication of first flush effect which has considerable control on water quality during flooding season. Ultimately, results will be used to 1) define contaminant 'risk zones' and 2) develop long-term mitigation strategies based on community awareness of runoff threats.

DECAPODS AS FUNCTIONAL FOOD FROM A VIEW OF ECOSYSTEM SERVICE AT PARANÁ RIVER BASIN, SOUTH AMERICA.

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Freshwater environments give services to society. Those related to health and human nutrition must be considered. Decapods are abundant in tropical and subtropical rivers. The work aim is to evaluate the nutritional quality of the decapods from the amino acids composition in muscle, considering as a functional food to improving man health. The decapods Macrobrachium borellii and Aegla uruguayana from Parana River Basin were sampled, and amino acids in muscle were determined after derivatization by HPLC, using D,L-α-aminobutyric acid as internal standard. Sixteen amino acids were determined, eight essential amino acids (EAA) for human, and the rest non-essential amino acids (NEAA). From the total AA, 38 and 40 % were EAA in M. borellii and A. uruguayana, respectively. The EAA have the following order; M. borellii: lysine > leucine > phenylalanine > valine > isoleucine > threonine > histidine > methionine; A. uruguayana: lysine > leucine > phenylalanine > threonine > isoleucine > histidine > valine > methionine. Both species provide the indispensable amino acid requirement for adults (FAO 2007). Regarding schoolchild/adolescent pattern, A. uruguayana has valine, and M. borellii has sulfur amino acids as limiting, 95 and 96 % of basic requirement for the group. Histidine and methionine in decapods were higher than sea and freshwater fishes (tuna, sardine, hake, carp, salmon, trout). Valine and isoleucine were lower than sea fishes, and only valine to freshwater fishes. Both species could be a functional resource to the feeding, improving health as a service of Paraná River Basin to society.

ECOLOGICAL EFFECTS OF HYDROPOWER DAMS IN ROMANIA AS REFLECTED IN SCIENTIFIC AND ENVIRONMENTAL IMPACT STUDIES

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In Romania, more than 460 micro-hydropower plants are in various stages of operation, approval, or construction. More than a quarter of them are located in or near protected areas. This poses a significant potential threat to the ecological integrity of Romanian rivers, which so far has not been reviewed in a synoptically way.
Hence, we performed a literature review on scientific articles and environmental impact assessment (EIA) studies reporting effects of river damming on aquatic biodiversity, mainly on fish, in Romanian rivers. Thus, a database on historic and present records has been developed, which includes field monitoring data of fish collected upstream and downstream of more than 50 dams from various rivers from all over Romania.
Available scientific studies show severe impacts of hydropower dams on the integrity of river ecosystems, as the modification of riverine habitats, modification of the hydrological regime, water temperature, turbidity, sediment load, interruption of river continuity.
In spite of those documented effects, the construction approximately 300 of such hydropower plants have already been approved. EIA studies often have bad quality, with a lack of a standardized methodology according to technical guidelines, and mostly lack a critical approach. EIAs only analyze local effects of hydropower construction, and don't estimate cumulative ecological effects.
Hence, we found a vast contrast between the conclusions of the scientific studies and the contents and conclusions of the environmental assessment studies which suggests the necessity to reconsider the whole existing methodological framework of hydropower plant approval in Romania.

ESTABLISHING HOLISTIC ENVIRONMENTAL FLOWS BASED ON ECOLOGICAL FUNCTIONS AND PROCESSES OF ALPINE FLOODPLAIN RIVER ECOSYSTEMS

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Worldwide, rivers are altered by abstraction and storage of flow. In this context, minimum flow regulations are applied to mitigate adverse impacts and to protect residual flow stretches from environmental deterioration. Mostly, however, only selected instream criteria and not those of the whole river ecosystem including its floodplains are considered. Based on essential functions and processes of unimpaired alpine floodplain rivers, we identify fundamental principles that must be adhered to determine truly ecologically-relevant environmental flows. A literature review shows that key aspects of the flow regime are necessary to preserve the integrity of alpine floodplain rivers. The natural flow regime and its seasonal components are primary drivers for functions and processes of abiotic and biotic elements, such as morphology, water quality, floodplain, groundwater, riparian vegetation, fish, macroinvertebrates, and amphibians. Based on the relationship between key elements of the flow regime and associated environmental components within as well as adjacent to the river, we establish an environmental floodplain flow (EFF) approach. EFF incorporates key elements documented in the literature which are necessary to maintain the functioning of alpine floodplain river systems. EFF underlines the importance of emulating the natural flow regime with its seasonal variability, flow magnitude, frequency, event duration, and rise and fall of the hydrograph. The application of principles laid out in the EFF approach enables a sustainable use of water resources while simultaneously ensuring the protection of natural functions and processes of alpine floodplain rivers.

HYDROPOWER DAMS IN SOUTH EAST EUROPE – DISTRIBUTION AND POTENTIAL ECOLOGICAL EFFECTS

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Currently there is a boom of hydropower (HP) dams in south-east Europe, which are even built in national parks and other protected areas. It is assumed that the ecological effects of these dam constructions will be even more harmful than in other regions, as south-east Europe represents a global hotspot of aquatic biodiversity.
In order to obtain an overview, we collected metadata on existing dams and on hydrological and biomonitoring stations of the area. In a second step, we attempt to obtain existing official monitoring data on hydrology, macroinvertebrates and fish from environmental agencies and from existing environmental impact assessments (EIA). Thus, we collated a database on all tributary rivers to the Danube in Slovenia, Croatia, Bosnia and Herzegovina (B&H) and Serbia.
It turned out that only few existing hydrologic gauges and biomonitoring stations are located near HP plants, which would be a prerequisite for scientific analyses on the effects of HP plants on the hydrology and ecology of rivers. Hence, suitable monitoring data are currently scarce and scattered. Data availability is especially poor for non-EU countries, especially for B&H. For many existing old HP plants no substantial EIA had been elaborated at their construction time, so that their ecological impacts have not been assessed adequately. We conclude that there is virtually no current knowledge on the ecological effects of small HP plants in south-east Europe, and only very few for larger ones. Hence, there is currently no knowledge basis existing for the elaboration of EIAs for future dams.

SMALL IS BEAUTIFUL? TRADING-OFF SMALL HYDROPOWER, ECOLOGY AND EVOLUTION

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Freshwater biodiversity is declining at unprecedented rates with habitat fragmentation and degradation being among the key drivers. The construction of small-scale run-of-river hydropower plants is booming despite limited knowledge of their local-scale and basin-scale impacts. Studies have shown that small hydropower plants have a higher ecological footprint per megawatt power produced than larger plants, mainly due to processes acting at larger scales. We therefore urgently need spatial planning tools that allow for comparing potential hydropower sites.

Here, we identify three research challenges for small hydropower affecting ecological and evolutionary dynamics with the aim to then develop better planning tools: (1) mechanistic understanding of ecological and evolutionary dynamics at the local scale, (2) impacts of multiple barriers on organism persistence at the basin-scale, and (3) importance of interactive effects with other anthropogenic stressors, such as eco-morphological alteration, land-use and climate change. Further, we'll assess the state-of-art of available spatial planning tools for hydropower site selection.

Small-scale hydropower may have the strongest impacts at the basin-scale with river fragmentation complicating organism dispersal and driving the decline of genetic diversity and locally adapted populations. Further, stressors like eco-morphological alteration also need to be considered when assessing potential hydropower sites. Despite the importance of large-scale processes, there aren't any effective planning tools available at present.

The highlighted research opportunities will improve our understanding and foster designing planning tools to achieve a high energy production at the lowest-possible cost for biodiversity and provision of ecosystem services.

INTCATCH: DEVELOPING INNOVATIVE SENSORS FOR ENVIRONMENTAL WATER MONITORING AND MANAGEMENT.

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Across the EU, regulators, policy makers and the water industry need reliable environmental data from which to assess and manage water quality. Such data may be expensive to provide and thus the EU Horizon 2020 funded INTCATCH Project http://intcatch.eu/ aims to provide a paradigm shift in monitoring and management techniques utilising a bottom up approach from Citizen Scientists and other stakeholders. The INTCATCH project started in June 2016 with twenty partners including regulators, researchers from universities, industry engineers and local community representatives.

The aim will be to utilise readily available sensors, linked to cost – effective ways of obtaining data such as by the use of autonomous boats. Not only will the equipment be able to determine routine water quality parameters in lakes and rivers from point and diffuse sources but it will be enhanced by using next – generation sequencing test kits, coupled with software data management tools. A Decision Support System will link water quality with other environmental parameters to provide a framework for smart catchment management..

Lake Garda in Italy, the River Ter in Spain, Yiki Lake in Greece, the River Ouse and urban rivers in London (UK) will be utilised to test the approaches. Cost effective and reliable environmental data will be compiled by citizen scientists and compared with regulator and industry derived data. At SEFS9, the importance of Citizen Scientists was presented and INTCATCH will utilise trained local community scientists to provide and interpret data in a timely manner.

TOWARDS ECOLOGICALLY RELEVANT NUTRIENT TARGETS FOR LAKES AND RIVERS OF EUROPE

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High concentrations of inorganic nutrients are a major factor contributing to the failure of many water bodies to achieve Good Ecological Status and Member States (MS) need to determine levels appropriate to their own territories. However, concerns have been raised about an apparently wide range of nutrient boundary values established by Member States. Inappropriate nutrient standards may hamper the ability of MS to achieve good ecological status, therefore it is important to set nutrient targets adequately.

At first, we have compared nutrient boundary values used by MS to support good ecological status for freshwaters (rivers and lakes) under the Water Framework Directive (WFD). Data, provided in 2014 by 28 countries on WFD boundary values for nitrogen and phosphorus, and methods used in deriving the values, were collated and analysed. There is considerable variability between MS nutrient boundaries, even within common types, one of the main factors behind these differences is different approaches to boundary setting used by MS.

Second, we have developed statistical methods for determining appropriate concentrations for supporting ecological status. These are:

- Regression analysis, using a continuous relationship between EQR and nutrient concentration;
- Categorical analysis, using the distribution of nutrient concentration within biological classes;
- Minimisation of mis-match of classifications for biology and nutrients.

Third, we applied these approaches to the common datasets in order to determine nutrient boundary values consistent with good ecological status for broad European types.

PUBLIC RECREATIONAL FRESHWATER ASSETS – CAN FRESH WATER ECOLOGY ASSIST POLICY MAKERS WITH MAKING SUSTAINABLE MANAGEMENT DECISIONS?

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The Sydney International Regatta Centre (SIRC) is a public recreational freshwater asset and was constructed under a partnership arrangement between the NSW State Government and Penrith Lakes Development Corporation. The lake is part of a wider network of lakes and its principal construction purpose was to host the Sydney 2000 Olympic Games - Rowing. Due to the success of the facility it continues to host major World Rowing Cup events. The SIRC consists of an 87 hectare competition and warmup lake established with an extensive submerged and emergent freshwater ecosystem to achieve a balance aquatic ecology.

Since the 2000 Olympic games the submerged macrophytes assemblages in the main competition lake have flourished and the water quality of the Lakes have met all primary contact guidelines for the majority of the year with minimum intervention or recurrent budget spend and no chemical treatment - an outstanding engineering achievement in a shallow constructed lake.

In 2014 the Policy makers determined that for recreational use and for serious sporting events the lakes macrophytes would need to be removed to allow for a clear 3 meter water column (or field of play) from the water surface down and attempted to remove the submerged macrophyte communities to achieve recreational targets. A range of methodologies were employed and this case study follows the trajectories of decline in interconnected lake aquatic ecosystem complexity, the resultant water quality outcomes, sediment loads and the implications for the riparian vegetation and water table of the management practice.

A META-ANALYSIS OF CONSEQUENCES IN WATER SCARCITY IN RIVER ECOSYSTEMS

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Water scarcity is occurring in many regions on Earth where the use of water resources is chronically in excess with respect to water availability. Water scarcity causes hydrological stress, expressed in flow intermittency, extensive alteration of the water flow regime, loss of peak flows, and prolonged low flows with respect to natural water regimes. These hydrological alterations have an unnatural origin, and may add to the existing natural stress in arid zones, or may be exclusively due to the misbalance in the use of water resources in other areas. Therefore, river systems with unnatural low flows and hydrological stability because of water scarcity may show general effects on the physical, chemical and ecosystemic features. The present analysis aims to identify the effects, directions and magnitudes of water scarcity on river hydromorphology (hydraulics, river-bed structure, channel geometry, sediment stability), water quality (temperature, nutrient concentrations, DOC concentration, fate and transport of contaminants), river biodiversity (effects for bacteria, algae, invertebrate, fish), and ecosystem functioning (primary production and respiration, organic matter decomposition). More than 1,000 papers have been examined, and the consequences for each of these response variables are described.

THE FRESHWATER INFORMATION PLATFORM (FIP) – AN ONLINE NETWORK SUPPORTING FRESHWATER BIODIVERSITY RESEARCH AND POLICY

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Species distribution data is crucial for improving our understanding of biodiversity and its threats. This is especially the case for freshwater environments, which are heavily affected by the global biodiversity crisis. Currently, a huge body of freshwater biodiversity data is often difficult to access, because systematic data publishing practices have not yet been adopted by the freshwater research community.

The Freshwater Information Platform (FIP; www.freshwaterplatform.eu) – initiated through the BioFresh project – aims at pooling freshwater related research information from a variety of projects and initiatives to make it easily accessible for scientists, water managers and conservationists as well as the interested public. It consists of several major components, three of which we want to specifically address: (1) The Freshwater Biodiversity Data Portal aims at mobilising freshwater biodiversity data, making them online available Datasets in the portal are described and documented in the (2) Freshwater Metadatabase and published as open access articles in the Freshwater Metadata Journal. The use of collected datasets for large-scale analyses and models is demonstrated in the (3) Global Freshwater Biodiversity Atlas that publishes interactive online maps featuring research results on freshwater biodiversity, resources, threats and conservation priorities.

Here we present the main components of the FIP as tools to streamline open access freshwater data publication arguing this will improve the capacity to protect and manage freshwater biodiversity in the face of global change. We further present the planned linkages to the newly established Freshwater BON of the GEO BON network.

HIDDEN HOTSPOTS OF CARBON PROCESSING IN GROUNDWATER-INFLUENCED INTERMITTENT STREAMS

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Groundwater contributions can play an important role in maintaining sub-surface baseflow in intermittent streams and rivers, potentially maintaining high rates of organic carbon (C) processing in the hyporheic zone during dry periods. The decomposition of organic C is a fundamental ecological process that underpins energy transfer throughout the biosphere. We assessed the ecological significance of baseflow permanence and groundwater contributions for driving rates of organic C processing in seven intermittent and one perennial stream spread across two climatic regions in eastern Australia. Leaf-litter packs and cotton-strip assays were deployed in paired surface and hyporheic locations in gravel bars, pools, and riffles at varying phases of hydrological connectivity. Processing of leaf material was consistently greater in hyporheic than surface environments in intermittent streams, and both leaf and cotton processing was greater in surface habitats subject to persistent saturated conditions. Leaf litter decay rates were, on average, greater than in studies in both surface and hyporheic environments of perennial and intermittent streams elsewhere. Finally, drawing on existing state and national mapping of groundwater-dependent ecosystems, modelled runoff, and mapped flow permanence, we show that groundwater contributions to non-perennial waterways are prevalent across a number of regions. Our results highlight that the hyporheic zone of intermittent river systems sustains critical ecosystem processes even when surface habitats cease to flow, and that the hydrological conditions facilitating these processes (i.e. groundwater-influenced intermittent rivers) are abundant throughout river networks. We discuss the implications of current and future groundwater drawdown and for catchment-scale C budgets.

GROUNDWATER DEPENDENT COMMUNITIES: RESPONSE OF BENTHIC, HYPORHEIC AND PHREATIC INVERTEBRATE COMMUNITIES TO A DROUGHT EVENT IN A CHALK CATCHMENT

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Drought events alter the aquatic environment though the contraction of habitat, reduction in connectivity and changes in abiotic conditions. The response of benthic invertebrate species to these events can alter the composition of this community, often resulting in reduced abundance and diversity; however, the response of fauna occupying the hyporheic and phreatic habitats to drought events is less well understood. This study assessed the composition and distribution of invertebrates occurring in benthic, hyporheic and phreatic habitats over 12 sites across the catchment of a groundwater dominated chalk stream in southern England during a drought event. The environmental conditions, specifically the abiotic variables and geochemistry, in each of the three habitats altered as surface water flow and groundwater levels declined over this period. More than one hundred invertebrate species, including Gammarus fossarum (Koch, 1836) a species new to the British Isles, were identified using morphological and molecular techniques. While the benthic community responded to the drought as expected, abundance in the hyporheic habitat increased while diversity remained constant, reflecting the movement of large numbers of a few epigean species into the subsurface. Although the abundance and diversity of the phreatic community remained stable over the study period, there were changes in the distribution and abundance of individual species as well as a large increase in the number of positive samples recorded following the recovery of groundwater levels. These responses suggest that the fauna recorded in each habitat responded differently to the drought event, and that many of these responses were species-specific. A greater understanding of the distribution and requirements of the species occupying groundwater dependent environments is essential for the conservation of these species and management of lotic ecosystems during disturbance events.

HYDROGEOLOGICAL CONCEPTUALISATION OF A MULTI-COMPONENT KARSTIC COASTAL WETLAND IN SW TURKEY: IMPLICATIONS FOR AN EFFECTIVE PROTECTION

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Sustainable management of groundwater dependent ecosystems requires implementation of an effective protection based upon ecohydrological system approach. A thorough understanding of the ecohydrological characteristics can be achieved by develoment of a representative hydrogeological conceptual model of the system. The Azmak coastal wetland situated in southwestern Turkey is defined as a groundwater dependent ecosystem and is under protection as one of the Special Protection Areas in Turkey. However, the protection zone has been delineated on the basis of the areal coverage of the wetland, ignoring the recharge-flow-discharge dynamics of the hydrogeological system. A detailed study to characterize and conceptualize the hydrogeological system revealed that the Azmak wetland is a multi-component ecosystem whose water sources are various not only in type but also in contribution to the wetland. The wetland was found to be fed by two karstic aquifers, one alluvial plain aquifer, one stream. Results of two-year insitu measurements and sampling of water components for hydrochemistry and stable isotopes have indicated that the contribution of each component to the wetland is not stationary but varies with time. The rate of sea water intrusion to the wetland is controlled by the temporal variation of the other components. This knowledge was interpreted to revise the current understanding of the ecohydrological working model of the Azmak wetland and to questioning the common protection strategy applied for aquatic ecosystems.

ECOHYDROLOGICAL ASSESSMENT OF IMPACTS ON HABITAT OF A CRITICALLY ENDANGERED FISH SPECIES IN ACIGÖL (TURKEY) GROUNDWATER DEPENDENT ECOSYSTEM

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The freshwater ecosystem that exists along the southeastern edge of a hypersaline Acıgöl lake in western Turkey, forms habitat for Aphanius transgrediens, a critically endangered fish species. The freshwater is supplied by the groundwater issuing from carbonate rock mass bordering the lake along a major fault. A number of freshwater springs issue along the major faults with various flow rates. Before reaching the saline lake, the spring waters flood the flat, lowland areas, forming a groundwater dependent ecosystem that extends as a 0.5 km wide strip along the major fault in the south. In spite of seasonal variation of discharge rates, the spring flow is permanent, maintaining the freshwater ecosystem the whole year. The current protection zone delineated around the freshwater ecosystem is proved to be ineffective, due to the fact that the applied approach disregards the ecohydrological characteristics of the system. Ecohydrological characterization of the ecosystem suggested that it is highly vulnerable against various anthropogenic stresses as well as natural impacts such as climate change. Ecohydrological approach applied have revealed that vulnerability of the freshwater ecosystem depends mainly on a) hydromorphological characteristics of the freshwater system, b) hydrodynamics of the carbonate rock aquifer, c) hypersaline lake dynamics and d) hydrometeorological variations. This paper discusses the shortcomings of common methods applied to delineate protection zones exemplifying the Acıgöl freshwater ecosystem and subsequently demonstrate the efficiency the ecohydrological system approach as a basis for an effect protection strategy.

AQUATIC MACROINVERTEBRATES OF SPRING-FEN HELOCRENES: SPECIES-RICH COMMUNITIES STRUCTURED BY ENVIRONMENTAL FILTERING

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Spring-fen helocrenes are nutrient-limited treeless wetlands fed by ground waters of variable mineral richness, constituting a sharp ecological gradient from calcareous to highly acidic conditions. These habitats were found to support species rich assemblages of various taxa groups, including many globally threatened habitat specialists and also glacial relicts. Our pioneer research at 62 of these habitats has proven the general assumption for the biota diversity as we have documented ca 600 aquatic macroinvertebrate species. These also include several very rare habitat specialists, found mainly among Diptera larvae. Exploring the importance of environmental and spatial processes on the metacommunity structuring we found local factors related to water chemistry and discharge to be outweighing the importance of dispersal limitations for all the studied taxa, but passively dispersing fen-habitat specialists. We also observed that species richness is shaped by contrasting mechanisms dependent mainly on the taxa habitat specialization. Although species richness of spring fen specialists was strongly determined by the main environmental gradient of groundwater chemistry, generalist species primarily reflected habitat stability linked to higher water discharge and habitat size. This can be related to a high habitat contrast of these isolated island-like sites, changing the main habitat filter for species well adapted to these conditions and species spreading from surrounding habitats. As these unique, ecologically specific and mostly small habitats are highly threatened by many human-made impacts, the richness of habitat specialists seen at calcareous fens indicates our conservation priority for aquatic macroinvertebrates inhabiting these systems.
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THE WITHIN-SITE VARIATION OF THE HARPACTICOID ASSEMBLAGES IN A WESTERN CARPATHIAN HETEROGENEOUS SPRING FEN

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The harpacticoid assemblages in the Western Carpathian spring fens have been studied so far on a regional scale, where several environmental variables (pH, January temperature and nutrients) have been identified to significantly influence the species composition of the assemblages. However, no information is still available on the response of spring fen harpacticoids to environmental conditions on a within-site scale, where environmental gradients are much shorter and where spatial segregation of species may occur as a result of interspecies competition. In this study, we examined the microdistribution of harpacticoids in the heterogeneous calcareous spring fen of Liptovská Teplička (central Slovakia). In spring, summer and autumn 2014 we quantitatively sampled five mesohabitats (pool, mud, tufa, moss, and brook bank) by taking 9 randomly selected samples per each mesohabitat, and measured relevant abiotic variables for each sample.
According to the preliminary results, there was a significant difference in the harpacticoid abundance between mesohabitats. The mud seemed to be rather unfavourable environment for harpacticoids, showing densities close to zero, in contrast to pool, where surprisingly high densities, exceeding hundreds of individuals per dm2, were found. We expect the species distributions to be highly patchy. To explain the distribution patterns we will use the spatial and environmental variables. We will test if species are spatially segregated to consider interspecific competition, especially between congeneric species (Bryocamptus). This work was supported by the research project of the Czech Science Foundation (P505/16-03881S) and Specific research of Masaryk University MUNI/A/1325/2015.

BIODIVERSITY PATTERNS AND CUMULATIVE IMPACTS OF MULTIPLE STRESSORS ON GREAT ARTESIAN BASIN SPRING WETLANDS

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Spring wetlands are a characteristic groundwater-dependent feature of the Great Artesian Basin (GAB) and have great ecological, scientific, socio-economic significance. Due to prolonged isolation, many GAB springs contain rare and endemic species of plants and animals that have undergone significant genetic differentiation and speciation. The springs are also important as drought refuge areas for much wildlife and as wetlands for migratory birds. However, development of the Great Artesian Basin over the past century by human activity has seen an overall decline in the flows from springs in many part of the GAB.
The ecological consequences of groundwater decline for GAB springs and the resident biota may be substantial but difficult to detect and potentially difficult to reverse. Furthermore, impacts of groundwater drawdown could greatly increase vulnerability to other existing and future threatening processes such as land use, livestock damage, invasive species and climate change.
Using available literature, ecological theory, unpublished data and expert knowledge, we conceptualise and quantify the environmental determinants of GAB spring endemic species composition and biodiversity patterns and assess how they respond to cumulative impacts of human activities and other stressors. We find that many species endemic to GAB springs have extremely restricted distributions, have very few populations within conservation reserves, and have high exposure to a range of threats. Many of these taxa are assessed as being highly vulnerable (i.e. low resistance and/or resilience) and therefore may be at substantial risk from threats associated with groundwater drawdown, introduced plants and animals and range of other stressors.

AN INDEX TO EVALUATE THE VULNERABILITY OF EPT-SPECIES IN ALPINE SPRINGS TO CLIMATE CHANGE

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In the Swiss Central Alps, a study of 61 rheocrenes between 1720 and 2515 m a.s.l. was performed, to identify the species, which vulnerable to 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 99 EPT species (Ephemeroptera, Plecoptera, Trichoptera) were found in the springs. Trichoptera showed an especially high proportion of crenobiont or crenophil taxa. The number of EPT and Trichoptera taxa was negatively correlated with the altitude and positively with the mean annual water temperature and the distance to permafrost. A CCA showed 27 Plecoptera and Trichoptera taxa living in springs of high altitude and especially cold water. Preference of high elevation, headwaters and spring habitats, endemism and short emergence period were the ecological traits were used to develop a value indicating the vulnerability for each species. A total of 88 (68%) of 126 evaluated species turned out to be moderately to highly vulnerable to climate change. A new climate change vulnerability index (CCVI) considering the specific vulnerability value of the occurring species showed 53 of the 61 investigated spring habitats as being vulnerable to climate change. This index can be used in addition to red lists to evaluate the threat of high elevation spring habitats for nature conservation purposes.

RIVER-GROUNDWATER INTERACTION IN AGRICULTURAL WATERSHEDS

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Most river basins of Po Plain (Northern Italy) are exploited for agriculture and animal farming, determining diffuse N pollution. River water quality worsens in stretches crossing areas with permeable soils and occurrence of springs. We hypothesize that N excess from fertilizers and manure, combined with flood-based irrigation over permeable soils could drive: 1) vertical N transfer to groundwater, 2) rise of the water table during irrigation period and, 3) replacement of low-nitrate river water used for irrigation with nitrate-rich groundwater. Aims of the work, part of the INTEGRON project, are to quantify the main N sources and sinks at watershed scale, evaluate the risk of water contamination and measure N-rich groundwater input to rivers. Soil N budgets were calculated for Adda and Ticino watersheds and were coupled to experimental field activities. During 2016 we performed reach-scale N balances by seasonal samplings of river water in segments crossing the springs area. At both basins, N sources (mainly
livestock manure and synthetic fertilizers) exceed sinks (mainly crop uptake), resulting in a soil N surplus and water contamination risk. In summer, during the irrigation period, where rivers cross the springs area, we measured a marked increase of nitrate in river water and we found that 90% of the rivers flow is diverted for irrigation practices. Concurrently, reach-scale N balances suggested diffuse ingression of nitrate-rich groundwater into the riverbed, replacing part of the abstracted water. Agriculture and animal farming produce an unsustainable pressure in the Po Plain and positive feedbacks for N pollution.

SUBSURFACE INTERSTITIAL AQUATIC ANNELIDS OF WESTERN CARPATHIAN SPRING FENS

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Spring fens in the Western Carpathians represent groundwater-fed micro-wetlands variable in their water chemistry. They host specific assemblages of aquatic annelids capable to inhabit both purely aquatic mesohabitats and water-logged soil mesohabitats. To explore the ability of individual species to penetrate into water-logged substratum, we studied the vertical distribution of aquatic annelids in the subsurface interstitial zone. Twenty seven spring fens in the Western Carpathians situated within the Czech and Slovak Republics were sampled in spring and autumn 2015 or 2016: 9 extremely mineral-rich fens with tufa, 8 mineral-rich fens without tufa, 5 mineral-rich Sphagnum fens and 5 mineral-poor Sphagnum fens. Five cores (17 cm2 each, 15 cm depth) were taken from water-logged mesohabitats (but without a surface water layer) at each site. In total, 1,135 individuals of aquatic Clitellata and 7,926 of Aeolosomatidae were collected. The highest numbers of aquatic annel ids were recorded in mineral-poor Sphagnum fens, the lowest in mineral-rich fens with tufa. The first 3 cm of substratum were inhabited by 54% of clitellates and 47% of aeolosomatids; their numbers decreased almost linearly with depth. Median depths at which individual species occurred varied from 1.9 to 10 cm. Preliminary results show that of 35 aquatic species previously reported from aquatic habitats (pools, spring brooks) of the same set of sampling sites, 18 were also recorded in the subsurface interstitial zone. These species seem to be well pre-adapted to survive a decrease of the water-table, which is the major threat to spring fen organisms. GA15-15548S and MUNI/A/1325/2015.

MICRODISTRIBUTION OF OSTRACODS IN A HETEROGENEOUS SPRING FEN

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In the last two decades, a number of studies on distribution of ostracods in European springs has been published, most of them on regional scale, concerning Alps, Mediterranean, Scandinavia and, most recently, Western Carpathians. At this large scale, chemistry of the spring water, flow regime and local climatic conditions have been usually recognized as the main factors affecting ostracod species composition. However, only little is still known about the drivers of ostracod species assemblages in springs on finer scale.

In this study, we examined the small-scale distribution of stracods in the heterogeneous calcareous spring fen Liptovská Teplička (central Slovakia) in relation to environmental variables. We found nine species of ostracods with different niche widths, from crenobionts (Cypria reptans) to ubiquists (Candona gr. negletcta). The gradient of mineral richness, significant at the large scale, was relatively short at the site, and therefore had a minor influence on the local scale. Almost all ostracod species showed strongly patchy distributions, but only few of them could be explained by the measured environmental factors. Water depth/temperature and amount of dissolved organic carbon were identified as significant factors, although they explained a relatively low percentage of the species data variance. Large part of the unexplained variability might be perhaps attributed to competition, distribution of predators or seasonality of some ostracod species, which is our next subject to study.

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THE ROLE OF PREDATORS IN SHAPING MACROINVERTEBRATE ASSEMBLAGES OF THE WESTERN CARPATHIAN SPRING FENS

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Due to the relative stability of environmental conditions in springs, spring communities have been considered to be at their equilibrium, being structured mainly by biotic interactions. The Western Carpathian spring fens (helocrenes) host very abundant and diverse macrofaunal assemblages, known to be significantly driven by environmental conditions and to a lesser extent also by dispersal limitations but the role of biotic interactions remains totally unexplored. Due to the absence of fish, the main “top-down” control in the spring fens is maintained by macroinvertebrates, especially amphipods and insects (e.g., stoneflies, some dipterans). In this study, we test the effect of macrofaunal predators on species density, richness and equitability in the macrofaunal spring fen assemblages on regional scale. We sampled two different mesohabitat types at 45 sites in spring and autumn and measured relevant environmental variables. Our main hypotheses were that 1) the predators reduce the populations of more abundant prey species by means of non-preferential feeding, thus increasing the species equitability and richness, and 2) that this relationship is stronger at the more stable mesohabitat.

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THREATS AND OPPORTUNITIES OF INTEGRATING ECOSYSTEM SERVICES IN NATURE MANAGEMENT

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Ecosystem services have become a mainstreaming topic in the research and policy agendas, and their relevance in nature management is dramatically increasing. Many have raised concerns on their use, as valuing nature from a utilitarian point of view might suppose a serious threat on biodiversity. Here, we review current knowledge on the relationship between biodiversity, ecosystem function, socio-economy, and monetary values of ecosystem services, discussing some of the most influential and less considered factors in this triangle: valuation strategy, services use and demand, individual revealed and stated preferences, and the spatial and temporal dimensions. After this review, we discuss the opportunities offered by the integration of ecosystem services in nature management that minimize the previously discussed threats on biodiversity: integrated management for human wellbeing and biodiversity, linkage of artificial and natural management elements, replacement of traditional grey infrastructures by nature-based solutions, and improvements in the life-cycle assessments in the framework of circular economy.

SPATIO - TEMPORAL ANALYSES OF MACROINVERTEBRATES, PLANKTON AND FISH ABUNDANCE IN WHIN ESTUARY IN GHANA

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A six month study of Whin estuary (longitude 10 48W and latitude 40 56N) reflects deteriorating quality of the water. This is capable of posing hazardous effects on life in the water and humans who depend on its resources. This system though has maintained pristine conditions over a long period of time in an area of intense human activities, requires serious attention since its status could further be magnified by threats emanating from the adverse effects of climate change. While the use of biotic indices is common in temperate waters, there is a lack of their use in Ghana probably because there is none developed for Ghanaian waters. The ecological status of the estuary will be assessed through the functional feeding groups and habit trait groups of macroinvertebrates, fish and plankton. Hydrographic factors, nutrients, Chlorophyl a, heavy metals and microbial assessment of water samples will be done following procedures of APHA (2009). The study seeks to identify the types and abundance of macroinvertebrates, plankton and fish present in the water; develop an appropriate pollution index for use for biomonitoring of wetland systems in Ghana and to develop a manual to train community leaders for use to monitor their water to enhance their livelihoods.

USING FUNCTIONAL FEEDING GROUPS OF TRICHOPTERA TAXA IN STREAM ECOSYSTEM ASSESSMENT STUDIES IN NORTHEASTERN ANATOLIA

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Two different approaches are used in biological evaluation of streams. While taxonomic approach requires a lot of time and effort, the functional approach is faster and better suited for understanding stream ecosystems. Trichoptera order is one of the most appropriate groups to use in stream ecosystem assessment studies, as it has a wide range of different taxa that use almost all feeding types.

In this study, Trichoptera specimens were collected from selected sampling stations of streams in Northeastern Anatolia which is located in biodiversity hotspot. These specimens were identified at the genus level and twenty-two genera were found. Feeding ratio of sampling stations were calculated according to the feeding behavior (shredder, predator, scraper, and collector) of these genera. The relationship between these ratios, and physicochemical properties of the stream (such as shading, riparian forest entity, ratio of riparion vegetation, altitude, substrate composition) was evaluated.

In River Continuum Concept, the model stream arises from forested area. Change of functional feeding groups ratio of Trichoptera was assessed along the stream system arising from above the tree line in Northeastern Anatolia. Different patterns in the distribution of functional feeding groups along longitudinal zonation in Northeastern Anatolia region has observed. The pattern could be used to assess the changes occuring in aquatic ecosystems.

TROPHIC TRANSFER EFFICIENCY IS THE MAIN DETERMINANT OF THE SLOPE OF COMMUNITY-WIDE BIOMASS-SIZE RELATIONSHIPS IN LAKES

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Biomasses of populations in ecosystems decline with increasing organismal size because larger organisms need more energy than smaller ones. The energy available for larger organisms is further limited by the energetic losses occurring while larger organisms feed on smaller ones. Therefore, a correspondence between the rate of decline of biomasses with size and the trophic transfer efficiency (TTE) in communities is expected. Community-wide biomass-size relationships are often expressed as Normalized Biomass Size Spectra (NBSS), a plot of logarithmic biomass sums within logarithmic bins of organismal mass, divided by the bin width. Theoretical explorations predict that the slope of the community-wide NBSS should be -1.0, if the TTE is around the commonly assumed 10%. We estimated the TTE in the four lake halves of two divided shallow lakes and calculated community-wide NBSS in the size range from bacteria to fish for pelagic and benthic organisms in three seasons of the year. In the four lake halves, the average TTE was substantially lower than 10% (range 1.0% to 3.6%, mean 1.85%). We confirmed empirically that NBSS slopes were correspondingly significantly smaller than -1.0 in all four lake halves, but differences of slopes between the lake halves and seasons were minor. However, the aggregated NBSS slope from all four lake halves was -1.17, hence matching the theoretically predicted slope of -1.18 for a mean TTE of 1.85%. The close correspondence between TTE and NBSS slope suggests that community-wide biomass-size relationships can be used to evaluate the efficiency of energetic transfer in lakes.

DOES MICROBIAL DIVERSITY DRIVE DECOMPOSITION IN BOREAL LAKE SEDIMENTS?

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Organic matter (OM) derived from terrestrial ecosystems influences both the food webs and biogeochemical cycles of lakes. The boreal ecozone holds an estimated 60% of the world's fresh water, but lakes in this region tend to be nutrient-poor and less productive, making them especially reliant on carbon subsidies from riparian litterfall. The availability of these carbon subsidies for aquatic food webs depends on microbial communities, but little is known about how the taxonomic and functional diversity of heterotrophic bacteria might influence the rate at which this OM is decomposed in natural systems. Drawing upon biodiversity-ecosystem functioning theory, we predicted that decomposition rates, indicative of both food web production and whole-lake carbon cycling, increase with the taxonomic and functional diversity of bacterial communities. We characterized both bacterial community composition and microbial functional traits in nearshore sediments from 8 catchments along a gradient of terrestrial OM inputs using next-generation sequencing (16S rRNA amplicon sequencing and shotgun metagenomics). We found that both OM quantity and bacterial abundance, and not taxonomic diversity, promote OM decomposition rates. Differences in species composition were largely driven by 17 bacterial families, with abundances of Acidobacteria, Firmicutes and Actinobacteria changing along OM gradients. Ongoing shotgun sequencing will provide more detailed information on the functional traits present in lake sediments. This study highlights the role of microbial communities in the transfer of resources from terrestrial ecosystems, and improves our understanding of how catchment disturbances affect boreal aquatic ecosystems.

NUTRIENT RETENTION IN RUNNING WATERS - DO LARGE RIVERS MATTER?

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The retention of nutrients during downstream transport is one of the most important ecosystem services provided by running waters. However, the majority of studies concerning riverine nutrient retention focuses on rather small streams, while data on large rivers are scarce. Several site specific characteristics such as nutrient emissions or hydraulic features (e.g. water residence time, hyporheic exchange rates, etc.) influence important retention parameters (e.g. denitrification rates), which therefore cannot easily be transferred from one river system to another. This leads to large uncertainties about the self-purification capacities of large rivers.

Based on empirical data and modeling approaches we assess the nutrient retention capacity along two contrasting sections of two large European rivers: the free flowing section of the Elbe and the impounded (German) part of the Danube. We discuss the challenges that are faced when translating turnover rates to ecosystem services, such as the uncertainties in upscaling of empirical data or the proper conversion to certain (monetary) valuation metrics. Furthermore, we show that comprehensive assessments of trade-offs are needed to prevent wrong conclusions about the ecosystem services provided by a certain river.

SERVING MANY MASTERS AT ONCE: ECOSYSTEM SERVICES IN DEEP MAN-MADE LAKES

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Intense sand mining has created numerous man-made lakes around the word in the past century. These small lake systems (1-50 ha) are usually hydrologically isolated and often deep (6 – 40 meters) and stratify during summer and in cold winters. Our study area is located in the catchment of the rivers Meuse and Rhine, in the southern part of the densely populated Netherlands. Due to their small size, these deep man-made lakes are usually not included in the regular monitoring campaigns, such as monitoring required for the European Water Framework Directive. Therefore, not much is known about their ecological functioning. Located in urbanized areas, these lakes play an important role in to day to day life of citizens (e.g. recreation, habitat for wildlife, drinking water supply, storm water retention). Therefore, they are not only potentially important ecologically (stepping stones in the urban landscape), but also important socially and economically.
During two summers, we measured the macrophyte diversity and a range of physio-chemical and biological parameters including water clarity and phosphate availability from sediment in 51 deep man-made lakes. Using this data, as well as data from citizen scientists, and local and regional governments a database was constructed to be able to assess the ecological functioning of the lakes in relation to the ecosystem services these deep man-made lakes provide. To this end, we carried out a suite of pattern analyses techniques, and developed a decision support system on how these lakes can be optimally managed to supply the desired ecosystem services.

BEHAVIORAL RESPONSE OF ROTIFERS TO UNFAVORABLE ENVIRONMENTAL CONDITIONS

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The distribution of most plankton organisms is confined by a number of abiotic environmental factors such as pH or salinity. The pH of lake water might vary substantially; temporally under eutrophic conditions due to high photosynthesis and nocturnal respiration, but also spatially over depth. When the actual pH is close to the niche edge of rotifers, it is essential to escape these unfavorable conditions. However, this requires the capability to perceive unfavorable conditions and to swim towards better conditions. Using small-scale laboratory experiments, the behavioral response of three rotifer species was analyzed in two pH-directions; below and above the pH niche. Two acidophilic species (Elosa worallii and Cephalodella sp.) and two neutrophilic (Brachionus calyciflorus and B. rubens) were investigated. In all cases, the rotifers were able to perceive unfavorable conditions and they actively swam towards favorable ones. Since, in contrast to light, favorable conditions cannot sensed from the distance, the underlying mechanism is more likely some kind of „random walk“ with a higher rate of turnings, when conditions are harmful. In a second step, conflicting environments were created with favorable pH and unfavorable salinity and vice versa. In these cases a more complex behavior was found.

ROBUST SOLID CONTACT ION SELECTIVE ELECTRODES FOR HIGH RESOLUTION IN-SITU PROFILING OF AMMONIUM, PH AND CARBON DIOXIDE IN EUTROPHIC LAKES

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Biogeochemical processes are often confined to very narrow zones in aquatic systems. In order to identify and study such processes, highly resolved measurements are required. Potentiometric solid contact ion selective electrodes (SC-ISEs) are promising tools for high resolution profiling of a variety of ions. While conventional SC-ISEs work well under controlled laboratory conditions they can fail to meet the challenges of natural water matrices. In-situ application requires SC-ISEs which are insensitive to changes in redox conditions, pH, and light and to reactive solutes like sulfide. We developed a design using different combinations of transducing materials and membrane matrices for fabrication of SC-ISEs selective to NH4+, pH, and CO2. With the use of modified multiwallcarbon nanotubes as a tranducing solid contact and an acryl based polymer as membrane matrix we built sensors that are insensitive to light and high sulfide concentrations.We integrated these sensors in a custom built in-situ profiling set up and successfully recorded high resolution profiles in the eutrophic lake Rotsee during summer stratification.

EARTH OBSERVATION-BASED SERVICES FOR MONITORING AND REPORTING OF ECOLOGICAL STATUS

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The H2020 project EOMORES will develop operational monitoring and reporting services for inland and coastal water quality based on a combination of the most up-to-date satellite data, innovative in situ instruments and ecological models.
Lakes, reservoirs and coastal water bodies constitute essential components of the hydrological and biogeochemical water cycles, and influence many aspects of ecology, economy, and human welfare, providing ecosystem services in multiple and sometimes conflicting ways. Knowledge about the state of inland and coastal water bodies is therefore of great interest.
EOMORES will develop information services to support international, national and regional authorities responsible for monitoring, management and reporting of water quality as well as private entities dealing with water quality such as dredging companies. These services will be based on Earth observation (Sentinel 1, 2 and 3), autonomous optical in situ sensors, and ecological models. The validated data from these components will be flexibly combined into higher-level products to fit the users' information requirements such as aggregated lake-wide indicators of the ecological status for Water Framework Directive reporting or early warning of cyanobacterial scums based on a combination of in situ measurements and model forecasts.
Three service concepts are envisaged: 1) operational water quality monitoring and forecasting for water management, 2) implementation of validated EO-based water quality indicators for WFD and other reporting and 3) historic compilation of data for specific ecological analysis.
The services are expected to result in lower operational costs, more reliable and more timely water quality data sets for water managers.

A SYSTEM ANALYSIS PERSPECTIVE ON MODELS OF LAKE METABOLISM

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Lake metabolism is most often followed by high-frequency measurements of dissolved oxygen, and simple conceptual models are used to couple oxygen dynamics to ecosystem-wide aggregated metabolic rates, such as the infamous net ecosystem production (NEP). The roots of this workflow date back to Odum. However, most conceptual models make strong yet implicit assumptions on the structure of the trophic chain or assume its certain elements to be in steady state. These assumptions and limitations often remain hidden from the users of the model and can only be revealed by comparing the model to an indeed general description of lake metabolism. We demonstrate that (i) common metabolic models suffer from hidden limitations, and therefore (ii) aggregated metabolic rates derived from oxygen dynamics correspond to different quantities depending on the actual structure of the lake ecosystem and the timescale of the analysis.

VALIDATION OF A MULTIVARIATE MODEL OF LAKE METABOLISM BASED ON DAILY RATE ESTIMATES OBTAINED FROM HIGH FREQUENCY DISSOLVED OXYGE

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High frequency time series of dissolved oxygen (DO), delayed chlorophyll fluorescence (Chl) and relevant background variables were recorded on nearly 1000 days during 8 years in large, shallow, meso-eutrophic Lake Balaton (Hungary). A novel dynamic model was developed for coupled simulation of diel dynamics of DO and Chl using sequential learning and uncertainty assessment in a Bayesian framework. As the application of the dynamic model was quite resource-intensive, a simpler statistical model was created to emulate simulated daily metabolic rates. The modelled daily rates of gross primary production (GPP) and community respiration (CR) were hindcasted assuming non-linear multiplicative dependence on daily mean Chl, water temperature and light. The hindcast was satisfactory for GPP and less successful for CR, possibly due to the impact of local benthic respiration. To validate the multivariate non-linear regression model, background data were used to predict GPP and CR during the last year of the study. Predicted metabolic rates were compared with rate estimates obtained by the Bayesian approach. As expected, GPP could be predicted with higher confidence than CR. The results suggested a major shift in lake metabolism at about 16 ˚C. Below and above this temperature limit, 70% and 90% of net primary production could immediately be utilized by heterotrophs, respectively.

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Validation of a multivariate model of lake metabolism based on daily rate estimates obtained from high frequency dissolved oxygen and chlorophyll data

THE NETLAKE METADATABASE – A TOOL FOR ASSESSING AUTOMATIC MONITORING ON LAKES IN EUROPE AND BEYOND.

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Sharing data is a keystone of collaborative science. A fundamental barrier, however, can be a lack of knowledge on what is being collected, at what sites, and by whom. The main aim of the NETLAKE (COST Action ES1201 - 2012-2016) was to build a network of sites and individuals to support development and deployment of automatic sensor-based systems in lakes and reservoirs within Europe. Working Group 1 developed a metadatabase of lakes and reservoirs which included data on where lakes were being monitored, together with details on the frequency and duration of monitoring, contact details, and the sensors being used. In total, metadata for stations on 67 European lakes has been captured to date. Twenty nine of these are Swiss lakes, many at higher altitudes, where only water temperature was measured. All other sites have stations measuring multiple parameters. Ten sites have data archives that span over a decade, seven of which are stations that had originally been deployed in the EU-funded REFLECT and CLIME projects in the late 1990s and early 2000s. In general, these stations in this database are being used for research purposes: only seven lakes were drinking water sources, while one was a very large Czech fish pond. GLEON, the Global Lake Ecological Observatory Network, and the pan-American SAFER project have also now agreed to add their sites to this metadatabase, and we hope that this metadatabase can be a tool for the wider community to promote high frequency monitoring in lakes and facilitate data sharing and collaborative science.

USING HIGH FREQUENCY MEASUREMENTS TO UNDERSTAND MIXED LAYER DYNAMICS IN EUROPEAN LAKES

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Mixing and stratification are fundamental drivers of many aspects of lake ecosystem function. Furthermore, the relative ease in which automated temperature sensors can be deployed means temperature profiles are one of the most common measurements taken from high resolution, in situ monitoring platforms in lakes. The recent proliferation of such lake monitoring platforms now provides a wealth of detailed data to investigate some of the most basic, but important, aspects of vertical temperature structure. We have, therefore, collected together several years' data from disparate European lakes to examine how well the concept of a mixed layer in a lake stands up to high frequency measurements. Similarly, we have tested the robustness of a variety of commonly-used definitions of mixed depth. The data have also enabled investigation of the diel, seasonal and inter-annual changes in mixed depths across European lakes. Further, combining these temperature measurements with high frequency meteorological data for the sites has allowed analysis of the influence of key atmospheric drivers on temperature dynamics in different lakes.

INTER-SEASONAL CARBON DYNAMICS OF OLIGOTROPHIC, SUBALPINE LAKE LUNZ, AUSTRIA

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Within lake catchments, organic matter (OM) is transported to lakes by inflowing water, retained in biota and sediments, respired, and also discharged into outflowing streams. In this multiannual field study (2013-2016), we investigate the quantity and biochemical quality of OM in Lake Lunz, Austria, as well as its CO2 emissions. We hypothesized that inflowing water and settling particles contain mostly recalcitrant particular OM (POM), whereas outflowing lake water is mainly composed of more labile, algae-derived OM. We collected OM at a monthly basis from lake in- and outflow, and as settling POM and in lake sediments. In addition, we assessed annual sedimentation rates (~1.1 mm a-1) and time integrated loads of settling particles to Lake Lunz (~50 t C a-1), analyzed stable isotopes to track changes in carbon sources and trophic compositions, and used source-specific fatty acids as indicators of allochthonous, bacterial, and algal-derived OM. Preliminary results indicate that inflowing POM is rich in terrestrial markers with little contribution of more labile autochthonous stream POM. However, POM in outflowing water contains clearly higher algae-derived fatty acids. The annual load of settling particles includes high contents of algae-derived OM, suggesting low degradation of such labile OM within the water column. Phosphorous concentrations remained stable throughout the sediment cores, implying that past changes in climatic forcing did not alter the load of this limiting nutrient in lakes. Ongoing research investigates how CO2 emissions from Lake Lunz compare with the seasonal flows of OM quantity and its biochemical quality.

UNDER-ICE DYNAMICS OF DISSOLVED OXYGEN FROM LAKE TOVEL (ITALY) BASED ON HIGH FREQUENCY DATA FROM THREE WINTERS

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In dimictic oligotrophic lakes, under-ice metabolism, dissolved oxygen (DO) dynamics and depletion are poorly understood. Here, we present high frequency (HF) data of under-ice DO dynamics measured at two depths (5 and 25 m) for three winters (January to March 2014, 2015, and 2016) in Lake Tovel, a small, montane lake (1178 m above sea level; area 38 ha; maximum depth 39 m). We assessed i) metabolic rates at a daily scale based on HF data for DO and light for winter 2016, and ii) DO depletion rates at a seasonal scale for all three winters. We applied different methods to estimate lake metabolism (i.e. book keeping and inverse modelling); in metabolic calculations, many days with low DO signals, zero light, and a nighttime DO increase had to be considered. We applied rigorous criteria of data management for lake metabolism calculations that resulted in many days with no metabolic rates. In agreement with its oligotrophic state and low dissolved organic carbon content, Lake Tovel was net heterotrophic. At a seasonal scale, DO concentrations at 5 m declined in 2014, remained stable in 2015 and increased in 2016, and these differences were linked to radiatively driven convective mixing. We hypothesise that coupling physical processes with lake metabolism will bring new insights to DO dynamics in ice covered systems.

PHYTOPLANKTON RESPONSES TO RECENT TEMPERATURE CHANGES IN PRE-ALPINE LAKE LUNZ, AUSTRIA

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Rapid increase in lake temperature recorded recently can affect planktonic populations by entailing a shift toward the dominance of warm temperature tolerant species (e.g. cyanobacteria). Such species are deficient in essential components, i.e. sterols and polyunsaturated fatty acids (PUFA), required for consumers growth and reproduction.
To increase our understanding of how changes in lake physics (such as temperature and mixing) affect phytoplankton composition and consequently the provision of dietary quality to consumers in pre-alpine oligotrophic lakes, we conducted a multi-annual lake study during three years (2013-2015) in the pre-alpine, oligotrophic Lake Lunz and investigated: a) the inter-annual dynamics of water temperature, mixing, and transparency, b) how lake physics affected the inter-seasonal changes in phytoplankton biomass and taxonomy, and, c) how the phytoplankton composition accounted for changes in nutritional quality, as assessed by its lipid and fatty acids (FA) composition. We found that the phytoplankton taxonomic composition in Lake Lunz remained fairly stable during the last years and provided high dietary quality, as assessed by PUFA, to consumers. This suggests that oligotrophic lakes, characterized by low seston quantity, but high dietary quality (i.e. high PUFA), may be less responsive to inter-annual weather changes than shallow and nutrient-rich lakes and are similar to pristine ecosystems as Artic ponds or ultra-oligotrophic lakes. This study may serve as a ‚baseline' for other pre-alpine lakes that concurrently undergo changes, as the case for other lakes worldwide, in an effort to assess short-term changes of phytoplankton and its nutritional quality for consumers at higher trophic levels.

ENGAGING CITIZENS IN LAKE MONITORING – A STEEP LEARNING CURVE FOR CITIZEN AND SCIENTISTS.

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Citizen science, in which scientist and non-scientis work together on scientific projects is recognized to be an important tool for public participation and engagement. Importantly, engaging with citizens will allow scientists to cover larger spatial and temporal scales, raise environmental as well scientific literacy, and bridge the gap between science and society. Levels of engagement can vary from crowdsourcing to participatory science, with joint efforts in problem definition and collection. Citizen science has entered a new era, as past expertise can now increasingly be combined with emerging technologies including apps on mobile phones.
Within the COSTaction NETLAKE we aimed at engaging citizens in lake monitoring, capitalizing on the potential of a network of lakes observatories throughout Europe. During an initial pilot, we explored several levels of engagement in water quality monitoring, working with different citizen groups, ranging from local school children to semi-professional divers associations. To gauge the interest of both scientist and citizens in collaborating in scientific project we conducted multiple (online) surveys, and had hands-on meeting with scientists and different citizen groups.
Based on the lessons learned during our initial efforts, we developed an extensive global citizen science campaign around two environmental challenges, carbon storage in aquatic systems and pollution by microplastics. Citizen groups from 11 countries monitored a suit of water quality parameters in 24 lakes, including microplastics, decomposition rate, high frequency temperature, water colour and transparency. Key to the success of our citizen science campaigns was self-organization with identification of citizen scientist champions, community building through hands-on meeting and social media, and having a reward system in place. By actively involving citizens in the whole process of doing lake science, we not only are able to work with citizens as sensors, but also increase environmental and scientific literacy of local end users.

ASSESSMENT OF CHANGES IN METABOLISM OF LAKE EYMIR WITH ENVIRONMENTAL VARIABLES USING AUTOMATED HIGH FREQUENCY DATA

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In this study, the data from automated high frequency lake motoring system is used to estimate metabolism for Lake Eymir which is located in cold-dry steppe climate. The automated system consists of two sondes, 7 temperature probes from surface to the bottom with a half a meter increment and the standard meteorological station. Concentrations of total phosphorus (TP), soluble reactive phosphorus (SRP), nitrate-nitrite, dissolved inorganic nitrogen (DIN) and total nitrogen (TN) were analyzed biweekly from the lake water. During the study period, there were drought 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 will discuss thoroughly how lake metabolisms responds to the environmental changes to be able to suggest better restoration measures.

JOINT SPECIES DISTRIBUTION MODELLING OF BENTHIC MACROINVERTEBRATE COMMUNITIES IN SWISS RIVERS

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Freshwater ecosystems and biodiversity face multiple growing threats due to increasing human demands on freshwater resources. To relate human activities to benthic macroinvertebrate communities, stream ecologists have applied species distribution models (SDMs) to describe how natural environmental conditions and human influence factors drive the distributions of invertebrates. While many existing SDMs focus on modelling the occurrence or abundance of individual species or biodiversity indices, there have been few efforts to jointly model entire communities of invertebrate taxa under a single model. Using existing literature and expert knowledge, we associate species with archetypes of presence-absence in response to both natural and anthropogenic influence factors, including stream temperature and flow velocity, river morphology, pollution from agricultural and urban sources, and other potential influence factors. We present the formulation and current state of results of a hierarchical statistical model that aims to jointly model the occurrence of invertebrate taxa in response to influence factors. Using Bayesian inference, we calibrate the model to monitoring data across Switzerland. We further explore the quantification of random effects within the model residuals, spatial autocorrelation, and biotic interactions among invertebrate communities. We will then apply the model to examine the effect of potential management strategies on invertebrate communities.

TACKLING THE SPATIAL AUTOCORRELATION PROBLEM IN THE EVALUATION OF THE DRIVERS OF METACOMMUNITY STRUCTURES

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The metacommunity framework has become a central theme in community ecology, illustrating how regional processes (dispersal) can complement local processes (species sorting) to shape connected local communities in a given landscape. Environment and species data can also be independently spatially structured due to stochastic processes (neutral dynamics) and the resulting spatial autocorrelation may lead to biased correlations of species distribution. Thanks to its simplicity and intuitive reasoning, the distance decay relationship (DDR) is the most widely used approach to disentangle the drivers of metacommunity structure. DDR examines the correlation through Mantel (and partial Mantel) tests between distance matrices obtained from community composition, environmental and spatial data. DDR is however criticized for its low statistical power and its ineffective inclusion of spatial autocorrelation. Here, we address this former issue using a new approach based on the construction of random variables with the same spatial structure than the real environmental variables (spatially-constrained null model). This approach is adapted to small samples and autocorrelated spatial or temporal series. Using simulated and real metacommunity data collected from intermittent rivers, where spatial autocorrelation is often high, we illustrate why spatial autocorrelation matters and how the proposed method allows to estimate the neutral part of the environment effect. Last, we illustrate how more robust inferences on underlying metacommunity processes can be made. Further research will develop tools to better account for the effect of asymmetry and unidirectionnality of flows in river networks.

JOINTLY ACCOUNTING FOR BIODIVERSITY AND ECOSYSTEM SERVICES FOR OPTIMIZING FRESHWATER MANAGEMENT: MODEL COUPLING

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Developing sustainable freshwater management strategies requires assessing the status of biodiversity while simultaneously accounting for ecosystem services. Here we exemplify the model coupling introduced in the previous presentation on a projection and optimization framework. This framework involves modelling biodiversity, ecosystem services and systematic conservation planning employing several models. A hierarchical Bayesian species distribution model (SDM) is used to simulate the potential occurrence of freshwater species within the study area (Intercontinental Biosphere Reserve of the Mediterranean Andalusia (Spain)-Morocco) with catchments as spatial units. Ecosystem services are modelled using the ARIES cyber-infrastructure yielding the spatial distribution and intensity of ecosystem services within the study area. The results from SDM and ARIES are then used as an input for Marxan with Zones that optimizes the spatial allocation of important management zones based on the combination of biodiversity and ecosystem services. In addition to the current situation, policy scenarios or management actions can be applied to project potential changes in important management zones given possible changes in biodiversity and / or ecosystem services. Assessing the spatial overlap and discrepancies together with near-optimal management zone solutions over time therefore has the potential to provide practical guidelines for management strategies.

HISTORICAL DISTRIBUTIONS OF DIADROMOUS FISH IN EUROPE

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Diadromous fish have very distinctive habitat needs throughout their life cycle that forces them to migrate between marine and freshwater ecosystems. The presence of artificial barriers, habitat destruction or degradation, overfishing, pollution and introduction of alien species are often mentioned as drivers of a global decline of diadromous fish that has been recorded since the beginning of the 20th century. Historical sources help researchers understand current and past ecological processes, which is a crucial step to implement effective management actions or define restoration targets. In this work, we determined the potential distribution of several European diadromous fish species at the beginning of the 20th century using historical data and empirical modelling techniques. Models used several static river features as well as historical climate and land-use data. The modelling procedure explicitly assumed a hierarchically structured effect among explanatory variables. We assumed that climatic variables operated at broader spatial scales than land use variables, which in turn acted at broader spatial scales than river segment features. Finer scale effects were treated after accounting for broader scale effects, following a two-step modelling procedure. By comparing the resulting potential distribution of diadromous species at the beginning of the 20th with the current known occurrence data we inferred possible causes for the decline of these species throughout the past century. Our results may be used as a diagnostic tool to help identifying management and restoration targets.

EVALUATING THE IMPACT OF BANK FILTRATION ON LAKE ECOSYSTEMS USING A SHALLOW LAKE MODEL

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Bank filtration, a water abstraction technology using different infiltration systems for groundwater recharge, such as river banks and lake shores, is a widely used method in many regions worldwide. For example, in Germany more than 300 water works use bank filtration and in Berlin, approximately 75 % of the drinking water is supplied with some form of artificially recharged groundwater, mostly bank filtrate from lakes. The research concerning bank filtration has almost exclusively focussed on the purification efficiency and infiltration capacity. Consequently, the knowledge about its presumed effects on lake ecosystems is very limited. We hypothesize that bank filtration can directly and indirectly (by cutting off groundwater inflow) affect a suite of lake characteristics. Physical parameters include temperature, flow patterns and water level while affected chemical parameters include availability of nitrogen and phosphorus as well as dissolved organic and inorganic carbon. Furthermore, bank filtration may also increase sediment clogging with organic matter and, associated, increased potential for oxygen depletion and reducing conditions in the sediment. These changes may have far reaching effects on different biological processes in lakes, increasing the risk to collapse to a turbid, non-vegetated state and occurrence of harmful blooms. Using the ecosystem model PCLake, we investigated the separate and simultaneous effects of potential bank filtration-induced changes of physical and chemical parameters on shallow lake ecosystems. Results partially showed a negative impact of bank filtration on lake water quality and a declining resilience against nutrient loading. Though, depending on initial conditions, especially nutrient loading, effects varied.

ANALYSIS OF SPATIAL PATTERNS IN FISH SIZE SPECTRUM THROUGH SPATIAL NETWORK MODELS

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The availability of accurate information about aquatic ecosystems is essential for their management and conservation. Most spatial statistical techniques applied to data measured on river networks are not optimized for streams because river networks are hierarchically structured, with nested watersheds, and stream segments connected by flow. Moreover, they should take into account the spatial configuration, directionality, connectivity and relative position of sites in a river network. Within this study we estimated the size spectrum of fish communities in up to 57 river reaches distributed along the whole river network of the Deva-Cares catchment (1200 km2) located in northern Spain. Our analysis is based in field data samples collected in 2014 during the low-flow season (August to October). We then used spatial statistical methods for river networks based on covariance structures to model fish size spectrum to all river reaches within the river network. These models use hydrologic distance, incorporate flow direction and allow covariance weighting when segments converge. We also used these models to analyze how fish size spectrum spatial patterns are constrained by different catchment and river reach characteristics considering multiple types of variables (hydrologic, habitat, basal resources type and availability, etc.). Our preliminary results show that spatial patterns of fish size spectrum are highly influenced by habitat characteristics and basal resource, being both dependent on their position within the river network. Additionally, we provide with a continuous spatial estimation of fish size spectrum for the entire river network.

TROUT POPULATIONS OF NATURAL AND BYPASS REACHES SHARE COMMON PROCESSES RELATING THEIR DYNAMICS TO THE ENVIRONMENT

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The structure and abundance of brown trout populations varies greatly among years and stream reaches. Among the numerous environmental key factors explaining this variability, the effect of floods is predominant but rarely quantified. Here, we summarise the results of a PhD thesis that aimed to identify the demographic processes and the influence of biotic and abiotic drivers structuring the age-stages of trout populations in time and space.
We used an extensive data set collected in 45 river reaches, including 22 located downstream a hydropower facility. Electrofishing surveys and detailed physical habitat characteristics (e.g. hydraulics, water temperature, cover) were available at all reaches.
Firstly, an analysis of the determinants of synchrony in densities at a large scale, pointed out that the recruitment of close populations (up to 75 km apart) could be synchronized by large floods during emergence of fry and/or by the remobilization of spawning substratum.
Secondly, the application of a deterministic trout population dynamic model, independently calibrated on nine reaches, revealed the influence of various local environmental drivers on population dynamics.
Finally, a hierarchical model involving all reaches showed that density-dependent mortality among juveniles and adults was a key biotic process. The strength of the competition was greater in absence of shelters and varied with water temperature.
The results of this work pointed out that trout populations share common processes that can be modelled as a function of quantitative environmental parameters. They provide a scientific basis to hydropower facility managers to reduce their influence on trout populations and respond to regulatory demands.

TRAJECTOMETRY OF FISH IN THE RHÔNE RIVER: MODELLING LINK BETWEEN ENVIRONMENT AND MOVEMENTS THROUGH BEHAVIOR USING TELEMETRY DATA

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Movement ecology aims to study the interplay between individuals and environments in their movement through the analysis of observed trajectories (e.g. velocity, orientation, direction changes) of individuals (Joo et al., 2013; McClintock et al., 2012; Nams, 2014). In their movement ecology paradigm, Nathan et al. (2008) assume that an individual movement is the result of four components: its internal state (why it is moving), its navigation capacity (when and where it is moving), its motion capacity (how it is moving) and the influence of environments. States-based models can analyze this interplay (Joo et al., 2013; Jonsen et al., 2013), and permitting relationships among environment/ behavior/ trajectory (e.g. avoidance behavior probability increases when discharge increases) to be modelled.
To investigate trajectometry of three species of freshwater fish in the Rhône river, we developed a model describing fish movements based on telemetry data at a very small temporal scale (3 secs). We linked movement variables and environmental factors (flow speed, water depth, temperature, ...) via fish behavior in state-space model based on Markov process, which allowed us to describe the response of several species to environmental variations (including anthropic impact). The first step of our work focused on data treatment. Then we estimated within the Bayesian framework the parameters of the state-space models that describes the trajectory of each individual. Finally, we integrated a hierarchical structure at the individual level to evaluate the intra-species variability of the response to environmental variations.

A NATIONWIDE SET OF HYDROLOGICAL METRICS AND PREDICTORS IN GERMANY

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Most analyses in freshwater ecosystems are limited by the restricted inclusion of hydrological predictors, especially regarding their spatial extent and temporal domain.
Furthermore, the required predictors are often regionally restricted or lack the required spatial resolution. To overcome these limitations we developed a simple hydrological model using daily discharge data from over 1000 river gauging stations throughout Germany. Three base models were built using predictors known to be highly correlated with river discharge: flow accumulation and monthly as well as seasonal spatially accumulated precipitation. The models were then applied over two spatial scales: for Germany in its entirety, as well as subdivided by regions (i.e. lowland, mountainous & alpine eco-regions). Two procedures, ordinary least squares regression (OLS) and regression through origin (RTO), were implemented within a robust linear model. A comparison was made between the outcomes of all model configurations, based on model skill. The gauging data were then extrapolated to a 1km gridded stream network. More than 100 predictor variables were calculated, covering the magnitude, frequency, duration, timing and change rate of high, low and average river flow conditions. Such data may serve as hydrological input variables for further analyses such as predictive modelling. Our approach also provides a more complete representation of freshwater ecosystems through hydrological predictors, known to be highly influential in the distribution of freshwater biota. Moreover, our approach uses globally available data for creating high resolution hydrological predictors and can therefore be easily applied to other geographic regions.

POTENTIAL VULNERABILITY OF STREAM MACROINVERTEBRATES TO GLOBAL CHANGE INDUCED HYDROLOGICAL ALTERATION

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Global change induced hydrological alteration is anticipated to affect species and communities of stream benthic invertebrates. Limited knowledge on species hydrological requirements hampers the vulnerability analysis of river reaches in terms of gaining/loosing taxa. We analyzed the potential vulnerability of river reaches to projected hydrological alterations in two model catchments in Germany, the Kinzig (central lower mountain region) and Treene (northern lowlands). Using the Soil and Water Assessment Tool (SWAT) we modelled high resolution daily mean discharge data given available gauging data and future climate change scenarios along the river network. We then calculated five hydrological metrics that provide information on magnitude, timing, duration, rate and frequency of hydrological events. We compiled benthic invertebrate sample data (Kinzig: 223 surveys, Treene: 95 surveys) and quantified hydrological traits and probability of occurrence of individual taxa according to current hydrological conditions using hierarchical logistic regression modelling. Potential future probability of occurrence was projected into 2070, and the difference in modelled probability of taxa occurrence along the current and future hydrological gradients was calculated for individual taxa at each sampling site. The magnitude of species responses then served as a metric to assess the potential vulnerability of river reaches to projected hydrological alteration. The results provide a quantitative description of taxa responses and their vulnerability to hydrological alteration, which is valuable for predicting potential impacts of changes in hydrology on taxa distributions.

WHICH TRAITS CAN INDUCE VULNERABILITY TO CLIMATE CHANGE? AN APPROACH USING DISTRIBUTION PREDICTIONS FOR DRUSINAE (TRICHOPTERA) UNDER FUTURE SCENARIOS

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The Drusinae subfamily comprises about 100 species distributed across Europe. Some species are widespread and common, while others are restricted to one of several regional centers of endemism, such as the Alps or the Balkan Highlands. Because they inhabit predominantly montane habitats, the Drusinae are regarded as particularly susceptible to changes in climate. This makes this large, running-water taxon an interesting group to assess climate change vulnerability through species distribution models (SDMs). We collated a dataset summarizing the distribution of 47 of the better investigated species, to project them according to four different future climate scenarios and based on 5 different global climate models. We then analyzed predicted future distribution patterns with regard to ecological characteristics as expressed by three ecological traits: larval feeding guild, stream zonation preference and level of endemism. We identified stream zonation preference, a non-phylogenetic trait, as an indicator of climate change vulnerability, as it was related to significant losses of predicted range, as well as altitudinal and centroid shifts in spring-dwelling species. Drusinae species with this trait are more numerous South of the Alps, specifically in the Balkan Peninsula. Our results underline the importance of continuous monitoring at the species level and highlight the need to draw the attention of freshwater scientists and conservation initiatives towards springs and low order streams. Further, many of the European biodiversity hotspots still require intense research efforts, such as the Balkan region, particularly in the context of environmental change.

JOINTLY ACCOUNTING FOR BIODIVERSITY AND ECOSYSTEM SERVICES FOR OPTIMIZING FRESHWATER MANAGEMENT: A PROJECTION AND OPTIMIZATION FRAMEWORK

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Aquatic ecosystems are rich in biodiversity and home to a diverse array of species and habitats that provide numerous economic and societal benefits. However, they have been and still are under a constant risk of being irreversibly damaged by human activities and pressures. These pressures threaten the sustainability of aquatic ecosystems, their biodiversity, the provision of ecosystem services and therewith human well-being; problems that we were not able to tackle so far, despite the implementation of various environmental directives. A promising way forward is Ecosystem-Based Management (EBM), an environmental management approach that considers social and ecological problems concurrently, consulting both scientists and stakeholders to find alternatives that enable a sustainable use of natural resources without jeopardizing freshwater ecosystems and biodiversity. However due to its complexity, EBM has rarely been operationalized in freshwaters. In my talk I will introduce a projection and optimization framework that will help to do so by modeling aquatic biodiversity and ecosystem services to forecast their development based on different scenarios. This information is used to optimize the spatial allocation of areas for biodiversity protection and ecosystem service delivery in the respective watershed, considering trade-offs and co-benefits among them. The framework considers multiple policy and stakeholder objectives for biodiversity and ecosystem services, their deficits, management alternatives and cost-effectiveness of management solutions. An on-ground application of the framework will be presented by Sami Domisch in the follow-up talk.

SIMULATION OF THE EFFECT OF RIPARIAN SHADING AND NUTRIENT REDUCTION MEASURES ON PHYTOPLANKTON IN MIDDLE ELBE BASIN (GERMANY)

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Scenarios with reduction of nutrient surplus and with increasing tree shading were run with model PhytoBasinRisk to simulate the longitudinal effect on phytoplankton development in main tributaries and Middle Elbe (Germany). Surface waters in the Middle Elbe basin receive high diffuse pollution and are under hydro-morphological pressure. Supported by specific environmental characters, such as extreme long residence times (river-lake-systems) combined with intensive land use in the riparian zones, the nutrient emissions are transformed effectively to phytoplankton biomass. In consequence the ecological status is less than good. How climate change will intensify this transformation, and which management options might be able reduce impact is tested with the model PhytoBasinRisk. The scenario concept is imbedded into the EU project MARS (Hering et al. 2015), in which three MARS –storylines are implemented. PhytoBasinRisk use spatial resolution and the output of two other models, which were successfully validated with baseline data of Elbe basin: i) hydrological model SWIM (Hattermann et al. 2015; Roers et al. 2016) which itself was based on regional climate models RCMs RCP4.5 and RCP8.5 and driven by the ISI-MIP scenarios GFDL-ESM2M and IPSL-CM5A-LR, ii) nutrient emission and transformation model MONERIS (Venohr et al. 2011), which was applied using these hydrological scenario conditions, and implement the MARS storylines via socio-economic changes in landuse and technical measures.

EFFECTS OF WARMING AND GRAZER DISTRIBUTION ON RIVERINE EUTROPHICATION CONTROL

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Benthic filter feeders (BFF) can reduce phytoplankton density thereby controlling eutrophication in shallow aquatic ecosystems, including rivers. However, the efficiency of eutrophication control depends on abiotic and biotic factors such as water depth, BFF distribution and initial phytoplankton concentration (hereafter: Pin value). Furthermore, experiments suggest that warming can alter eutrophication control by grazers by shifting the relationship between BFF grazing rate and the growth rate of planktonic prey. To test how such control changes with temperature under the influence of water depth, Pin value, BFF density and spatial BFF distribution, we developed a spatially-explicit simulation model. Our model includes the thermal responses of BFF grazing and phytoplankton growth. Results show that BFF grazing can qualitatively alter and, under some conditions, reverse phytoplankton response to warming. Moreover, grazing-controlled phytoplankton responds non-linearly to warming, depth and Pin value and its density may increase steeply with slight changes of these variables. Furthermore, BFF distribution determines grazer control of phytoplankton. However, the effect of such distribution depends on temperature, depth, Pin value and BFF density. In conclusion, this work shows that trophic control can strongly alter the response of eutrophication to warming. Therefore, the prediction of global warming effects must consider trophic interactions. In addition, this study shows the importance of interactions between abiotic and biotic factors, including spatial distribution, in eutrophication control.

ECOLOGICAL MODELLING TO SUPPORT ENVIRONMENTAL MANAGEMENT DECISIONS

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Supporting environmental management decisions often involves the prediction of ecological consequences of different management alternatives. Such predictions may base on recommendations from experts, on the transfer of experience from similar cases, or may involve modelling approaches. In the field of freshwater management, various modelling approaches exist to predict the response of aquatic ecosystems to anthropogenic impairment. They range from very simple linear to complex nonlinear models, include deterministic and stochastic formulations, and can be statistical and/or process based. Independent from the chosen approach, some basic requirements should be fulfilled, especially if decisions need to be justifiable to the public. These include:

- a (basic) mechanistic understanding of the system (regarding causality)
- predictor variables that can be linked to management alternatives
- disentangling confounding factors
- a quantification of uncertainty
- transparency of the modelling procedure and the model assumptions made

Furthermore, if management decisions have long-term consequences, it might be necessary to account for potential future changes in the ecosystem independent from environmental management.

In this introductory presentation, we will discuss suggestions and limitations when addressing these challenges in ecological modelling to support environmental management decisions.

A TRAIT BASED MODEL OF MACRO-INVERTEBRATE COMMUNITY COMPOSITION IN SWISS RIVERS UNDER MULTIPLE STRESSORS

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Multiple human and natural influence factors affect invertebrate communities in rivers, with knock on effects on ecosystem functioning and goods and services provisioning. Despite well-developed knowledge on invertebrate-environment interactions and the availability of Swiss wide biomonitoring data, critical issues remain in disentangling effects of multiple stressors and moving towards understanding that is applicable across river basins with different taxonomic compositions. We aimed to test and improve current understanding of how community composition or macro-invertebrates in rivers is influenced by environmental factors that change across natural and anthropogenic gradients. Therefore, we formalized expert knowledge on invertebrate-environment interactions, available in trait databases, to predict the probability of occurrence of taxa within characteristic communities at sites throughout Switzerland. We derived direct environmental factors that describe local habitat conditions from indirect environmental factors including land use, pollution sources, river morphology and topography. Local environmental conditions were then combined with data on trait preferences for each taxon to derive a habitat suitability for each environmental factor and taxon at each site. Additional factors such as the spatial context of the site, the regional species pool and observation errors will be taken into account. The model was calibrated with monitoring data using a generalized linear model and Bayesian inference was used to validate and improve knowledge on trait preferences of individual taxa. The model allows a test of cause-effect relationships for different human stressors and allows synthesis, testing and improvement of current trait knowledge. We aim to apply the model in decision support for river management.

DIRECT AND INDIRECT EFFECTS OF MULTIPLE STRESSORS ON STREAM FAUNA ACROSS WATERSHED, REACH AND SITE SCALES: A PATH MODELLING ANALYSIS REVEALING THE ROLE OF HYDROMORPHOLOGY.

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The purpose of our approach was to take into account the nested scales of stream functioning in the analysis of the links between anthropogenic pressures and stream ecological status by building and analysing a hierarchical model. The development of this model aimed at answering the following questions: Do the indirect links between pressures and ecological status modify the pressure impact hierarchy? Does each nested scale play a different role in the pressures-ecological status relationship? Has the model the potential to provide better understanding of the specific role of hydromorphology in ecological status evaluation?

In this framework, we used the PLS path modelling method for developing a structural model linking the latent variables of (i) land use and hydromorphological alterations at watershed scale, (ii) hydromorphological alterations at reach scale, (ii) nutrients-organic matter contamination levels, and (iv) substrate samples to explain score variations of the French macroinvertebrate-based index I2M2 (Mondy et al. 2012).

The importance of both direct (on hydromorphology and physico-chemistry) and indirect (on stream biological condition) effects of land use have been highlighted. We have also demonstrated that hydromorphological alterations have an effect on both substrate mosaic structure and nutrients/organic matter concentrations. This result implies a major indirect effect of hydromorphology on macroinvertebrate assemblages. Finally, the nutrient and organic matter effects on macroinvertebrate assemblages could be considered as lower than expected, when compared to all the indirect effects of land use and hydromorphological alterations.

UNDERSTANDING THE PRODUCTION OF TASTE AND ODOUR COMPOUNDS IN RESERVOIRS: A WATER INDUSTRY PERSPECTIVE

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A consistent increasing trend in the occurrence of the taste and odour compounds Geosmin and 2-Methylisoborneol (MIB) have been observed in Welsh drinking water reservoirs since the beginning of the decade. These include bodies of variable water chemistry and catchment land use patterns, such as lowland agricultural areas and upland oligotrophic reservoirs with no history of cyanobacterial blooms. There are a number of issues with the removal of these compounds via water treatment, such as high chemical and power costs, sludge disposal, need for space and planning permission in protected areas. A double approach to manage this problem included a 'bottom-up' one, by investigating the origin of the problem to identify solutions, and a 'top-down' approach, by trialling existing reservoir management techniques such as destratification via stirrers and ultrasound to reduce targeted algal populations. This presentation will focus on case studies where the afore-mentioned approaches have been tested in a number of reservoirs in Wales. Preliminary findings include the production of MIB by planktonic Anabaena, the co-production of Geosmin and MIB by benthic Oscillatoria, the impact of a Resmix system on mass fluxes of both compounds and the unintended impacts of mixing to the dynamics of metals in one of the reservoirs.

OXYGENIC PRIMARY PRODUCTION CLOSE TO THE OXIC-ANOXIC INTERFACE IN HYPERTROPHIC LAKE

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We investigated the oxygenic primary production (OPP) in the 16 m deep hypertrophic Lake Rotsee. In-situ primary production was measured using 14C incubation in combination with high resolution profiling of oxygen, temperature, photosynthetically active radiation (PAR) and chlorophyll-a. In addition, samples were taken to identify the community composition of primary producers. The spectral composition of light was measured in the photic zone of the water column at distinct depths. Preliminary results from a dataset recorded in fall show that OPP occurs even in zones where no oxygen was measured and PAR values were as low as 0.34 µE m-2 s-1. In this zone Cyanophyceae were the dominant class of phototrophs while the euphotic zone was dominated by other classes like Chlorophyceae. Depth-integrated OPP rates below the oxycline of 1.5-2 mmol m-2 d-1 corresponded to 8% of the oxygen flux across the oxycline. The occurrence of oxygenic primary production in the virtually anoxic zone suggests the existence of primary producers which are well adapted to very low light conditions. Chlorophyeceae are well known for such an adaptability. The absence of measurable oxygen in this zone can be explained by a high potential oxygen demand resulting in an immediate consumption of the oxygen produced.Even though production rates are fairly low, OPP in the anoxic zones in lakes may form a distinct habitat for heterotrophic organisms adapted to very low oxygen conditions.

FOREST AS A MAJOR SOURCE OF ORGANIC MATTER IN MONTANE RESERVOIRS IN ASIAN MONSOON REGION

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A significant amount of woody debris is exported from forest watersheds into Korean reservoirs due to the combined effect of heavy rains during summer monsoon and high slope topography. The export of woody debris, fine POC, and DOC were measured in a forest stream in order to quantify the exports from forest watersheds. POC varied drastically according to rain intensity; most of debris was discharged during a few episodic rain events which exceeded 100 mm rainfall. The amount of POC export was similar to DOC export. Export rate of organic matter was measured to be 35.7 kg/ha/yr for TOC, 11.4 for DOC, 13.9 for fine POC, and 10.4 for coarse POC, which shows POC export is larger than DOC export. It was found that leaves settle down in the upstream region of reservoirs. Settled leaves formed thick layers of organic sediment at the lake bottom and caused methane ebullition in some reservoirs. In the lab experiment leaves could release organic matter and nutrients significantly. However, when the settled leaves were covered with 3cm sediments, sediment capping seems to block the release of DOC and phosphorus. Dissolution of methane was also blocked by sediment capping, but methane could escape from sediment by ebullition. In montane reservoirs of Korea, COD is much higher than expected from TP concentration, even though watersheds are not inhabited and there is no anthropogenic pollutant source. In conclusion woody debris can be a major source of organic carbon and greenhouse gas in Korean reservoirs.

WATER QUALITY IMPACTS IN THE CONTEXT OF CHANGING OPERATION MODE OF A PUMPED-STORAGE HYDROPOWER PLANT

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The nuclear accidents in Fukushima resulted in rethinking energy policy in Europe with a focus on increased promotion of new renewable electricity sources. These sources are of intermittent nature, which needs to be compensated by storage-capacity. Pumped-storage hydropower plants are a well-established option for such energy storage.
These pumped-storage hydropower plants affect physical, biogeochemical as well as ecological properties of the linked water bodies, which include artificial reservoirs as well as natural lakes. Especially the impacts on natural lakes need to be limited to keep lake ecology intact.
Previous modeling studies focused on determining impacts on lake stratification as well as particle dynamics, whereas this study also quantifies the impacts on water quality. We used a two-dimensional model to project the effects of a pumped-storage hydropower plant between Sihlsee (upper reservoir) and Upper Lake Zurich (lower lake) in Switzerland on temperature, stratification, oxygen concentrations, as well as nutrient content in the two connected water bodies. Different operating scenarios are simulated using this model. For the scenarios the increasing flow due to pumping water from the lower lake to the upper reservoir results in an increased dissolved oxygen concentration at the hypolimnion of the upper reservoir in summer.

THE IMPACT OF TOP-DOWN IMPELLER-BASED CIRCULATORS ON STRATIFICATION IN COTTER RESERVOIR

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Impeller-based systems (e.g. SolarBee and WEARS) to enhance circulation in lakes and reservoirs promise a more energy efficient alternative to the compressed-air bubble plume method of reservoir destratification. Both methods work by displacing large volumes of water vertically and then allowing gravitational forces and entrainment to produce large scale circulation in the water column - typically as an intrusive flow bounded above and below by return flows towards the vertical plumes. Anecdotal evidence suggests such systems can have profound effects on reservoir water quality yet there has been little rigorous study and assessment of their performance.

Cotter Dam, a water supply storage for Canberra, Australia, has recently been augmented from 4 to 80 GL by construction of a new dam which has raised the full storage level by ~ 50 m and inundated sensitive breeding habitat for the endangered Macquarie Perch. Due to a devastating bushfire in 2003, severe catchment erosion and resultant organic matter loading to the reservoir has caused acute anoxia below 4 m depth during summer of most of the following years. To ensure adequate dissolved oxygen is always available in the Macquarie Perch habitat, 3 pairs of WEARS top-down circulators fitted with 7 m-long draft tubes commenced operation in December 2014.

Two years of thermistor chain, meteorological and water quality profiler data illustrate the impact of the mixers on thermal and oxygen stratification in the water column. Plume dynamics and the resultant mixer-induced changes to thermal stratification, surface mixed layer depth and oxygen concentration in the water column will be discussed.

THE SPATIAL EXTENT OF MIXING AND TURBULENCE INDUCED BY A SURFACE MIXER AT DURLEIGH RESERVOIR, SOMERSET, UK

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To reduce the effects of thermal stratification on drinking water quality, utilities are increasingly investing in surface mixing destratification systems. In England and Wales since 2013, four utilities have installed 11 surface mixers (SMs) in their water supply reservoirs. Theory dictates that SMs destratify the water column by pushing surface waters to the bottom of the reservoir creating water column convection, which prevents stratification. However, the spatial extent of mixing and turbulence induced by SMs within reservoirs has not been assessed. Here, temperature microstructure profiles are examined along a horizontal transect of increasing distance downwind of a SM installed at Durleigh Reservoir (max depth 5.5m), Somerset, UK. Profiles show high levels of turbulence throughout the water column along the transect, and turbulence increases with distance from the SM. Near the mixer, a complex turbulence profile was observed with a peak of 10-6 m2/s3 near the surface and 10-6.5 m2/s3 in a local maximum between 3-4m, with minimum values reaching 10-7.5 m2/s3. At the location furthest from the SM, the profile is more uniform with values consistently between 10-7-10-6 m2/s3. Mixing estimates following the Osborn-Cox method reveals high mixing throughout the water column, with mixing decreasing with distance from the mixer. Near the surface, mixing values decrease with distance from the mixer from 10-3.5 to 10-5 m2/s3. Typical values of background turbulence in natural lakes are expected to be around 10-7 m2/s3 at the surface and 10-9 m2/s3 in the interior. The values presented are an order of magnitude greater, highlighting the gap in knowledge of the hydrodynamics associated with SMs.

Key Words: Destratification, Surface mixer, turbulence, temperature microstructure, water quality

LONG TERM TRENDS IN PHOSPHORUS CONCENTRATION IN A WATER RESERVOIR: SOCIO-ECONOMIC AND CLIMATE CHANGE DRIVERS

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Freshwater ecosystems have undergone significant human-induced and environmentally-driven variations during the last half-century, mainly in connection with changes in nutrient export from the catchment and with changing climatic conditions. The research focused on the analysis of variation of total phosphorus concentration (TP) in the Slapy reservoir, Czechia, and its socio-economic and climate drivers during the period from 1963 to 2015. Data analysis was supported by conventional statistical tools and identification of breaking points applying a segmented regression. Results indicated clear seasonal patterns of TP, its annual increase till 1991 and decrease from 1992 to 2015. The trends in winter and spring TP in the Slapy reservoir were found to reflect regional socio-economic changes, such as phosphorus export from households, application of fertilizers, livestock production and sewage infrastructure development. The summer TP has been associated with variations of water flow since 1990, when TP started to increase due to extreme hydrological events. This phenomenon could be explained by more frequent disruptions of thermal stratification and mixing of deeper layers rich in TP. An increase in water temperature has been recorded since 1987, correspondingly to air temperature trends. The epilimnion temperature was more sensitive to climate variations than the hypolimnion temperature. The long term temperature increase and changes in flow conditions can hence change seasonal TP trends and might result in more eutrophic conditions of the reservoir.

OPTIMIZING WITHDRAWAL FROM DRINKING WATER RESERVOIRS TO COMBINE DOWNSTREAM RIVER DEMANDS WITH A SUSTAINABLE RAW WATER MANAGEMENT

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reservoir management, reservoir modelling, selective withdrawal, thermal stratification, hypolimnetic dissolved oxygen

EXTREME SPATIAL AND TEMPORAL HETEROGENEITY OF CH4 AND CO2 FLUX RATES IN TEMPERATE SHALLOW PONDS.

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CH4 and CO2 emitted from freshwaters are significant component of the global carbon cycle. While recent estimates paid special attention to flux rates of both gases from lakes and reservoirs, small and shallow ponds received less attention. Moreover, measured and modeled flux rates are subject to high uncertainty caused by low spatial and temporal measurement resolution. Using a continuous measurement approach of flux rates and weekly measurements of dissolved gaseous of CH4 and CO2 in a small and shallow pond in Southwest Germany, our results revealed high variability of flux rate for both gases within small (0.5m) spatial and short (1hour) temporal scales. The pond was characterized by high dissolved gas concentrations with partial pressures of CH4 ranging from 46 to 400 ppm and CO2 ranging between 620 and 4280 ppm. Ebullition was the major flux path for CH4 (80-fold higher than the diffusive flux), and varied between 0 and 32.5 mmol CH4 m-2 d-1. The observed strong variation of CH4 and CO2 fluxes within few meters and subdiurnal time scales, emphasizes the need for high flux measurement resolution.

TIME OF DAY MATTERS – DIURNAL CHANGES OF CO2 FLUXES ACROSS EUROPEAN STREAMS

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Running waters are major CO2 emitters, accounting globally for approximately 70% of the total flux from inland waters. Nonetheless, the magnitude and mechanisms of these fluxes are still not adequately quantified or understood, contributing to a high uncertainty in

small- to large-scale carbon budgets. In the EuroRun project ("Assessing CO2 fluxes from European running waters"), representing the 1st Collaborative European Freshwater Science Project for Young Researchers initiated by the European Federation of Freshwater Sciences board, the European Fresh and Young Researchers, and representatives of the Fresh Blood for Fresh Water meetings, we aimed to assess spatial and temporal variability of CO2 fluxes from European running waters. A team of early career scientists from all over Europe measured CO2 fluxes with drifting flux chambers equipped with CO2 mini-loggers. We performed the measurements in 11 countries in 34 streams at day and night within coordinated periods covering several seasons. Altogether, the investigated European streams showed both CO2 uptake and emissions with a higher frequency of emissions. Furthermore, for the majority of the studied streams we recorded higher CO2 fluxes at night, while some streams even turned from a sink of CO2 during the day into a source of CO2 during the night. Our results highlight that the time of measurement is important to accurately determine CO2 fluxes from streams and future efforts to upscale those fluxes should include day and night-time measurements from running waters.

SS06 – Poster

BENTHIC METHANE FLUXES THROUGH THE SEDIMENT-WATER INTERFACE OF A LOWLAND RIVER

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There is a paucity of data concerning sources of methane (CH4) to the fluvial freshwater ecosystems, despite of their significant contribution to global CH4 flux. River sediments are one of the important sources of CH4 to surface water, however combination of the multiple factors results to high spatiotemporal heterogeneity of CH4 fluxes and their quantification and extrapolation is rather complicated. In this study the investigation of relationships between surface sediments and CH4 supply to the surface water has been conducted for the various river habitats in order to compare the sediment samples with significantly different abiotic and biotic parameters. Three main issues have been measured - environmental parameters of sediments; potential capacity of sediments to produce or consume CH4 and the directly measured CH4 diffusion through the sediment-water interface using benthic chamber method. The CH4 diffusive fluxes to the surface water showed high spatial variability and ranged from 0 to 27.3 mmol CH4 m-2d-1. In general we observed three main model situations of sediment-water interaction. High CH4 fluxes were observed, when the CH4 production potential of upper sediment layer was high, and the CH4 concentration was increased in both upper (0-10 cm) and lower (20-30 cm) hyporheic interstitial water. On the other hand, CH4 diffusive fluxes were significantly lower or zero when either the only upper or the only lower sediment layers were CH4 productive and interstitial water was enriched with CH4. The CH4 oxidation in sediments probably prevents CH4 release to surface water in the last two mentioned cases.

DISSOLVED ORGANIC MATTER QUALITY DRIVES MICROBIAL RESPIRATION

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Microbial respiration (R) is a major contributor to carbon dioxide (CO2) emissions from freshwaters. Herein, terrestrial dissolved organic matter (DOM) is one of the main substrates for R, whereby its availability is linked to its molecular composition, i.e. quality. Future hydrological changes will likely alter both quantity and quality of DOM exported from terrestrial sources to freshwaters. However, a controversy exists on the importance of DOM quality in the microbial mediated carbon cycle in these systems. This study aimed to (i) understand how two specific terrestrial DOM sources with distinct qualities and different mixtures (mixed in different proportions) influence R, and (ii) explore driving factors of R. We performed a short-term incubation experiment, mixing two terrestrial substrates of contrasting 13C isotopy and quality at different proportions but the same concentration to a natural microbial community inoculum. The substrates were a highly available (labile) isotopically labelled beech leaf leachate (DOMleaf) and a refractory peat leachate (DOMpeat). During the experiment, we measured R intensity and isotopic signature (d13C), dissolved nutrients, and DOM quality characteristics. We observed a strong treatment-effect on R, while the quantity of emitted CO2 significantly increased with increasing proportion of labile DOM (DOMleaf). Thereby, isotope analysis showed that the observed stimulation in R was dominated by decomposition of DOMleaf. The DOM quality characteristic molecular weight was the strongest predictor of R. Our results suggest a tight linkage between R and DOM quality, indicating that labile terrestrial DOM likely supports high levels of R and consequently CO2 emissions of freshwaters.

CARBON BALANCES AND THE ROLE OF MEDITERRANEAN WETLANDS IN GHG EXCHANGE

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Compared to other types of ecosystems, wetlands globally contribute in a disproportionate way to global balances of carbon and GHG. Although these balances have been determined for several types of wetlands, the role of Mediterranean wetlands on GHG exchange with the atmosphere is largely unknown. Within the framework of the CLIMAWET and CARBONNAT projects, we are conducting an extensive survey of the main processes and determining factors related to the carbon cycle in the main types of Spanish Mediterranean wetlands, whose results will be modeled and, then, extrapolated to the overall country wetland coverage. Factors such as the salinity, temperature, nutrient level, and the hydroperiod features differentially influence these balances. Part of them are strongly linked to management modes that could be selected to increase the role of these wetlands in climate change mitigation through regulation of their carbon sequestration capacities and GHG emissions. The response of different biological (photosynthesis, aerobic respiration, methanogenesis), chemical (e.g. DIC dynamics) and physical (e.g. gas fluxes) differ among different environmental conditions, all these processes determining the carbon and GHG balances. This also occurs differentially in different types of wetlands. For instance methane emissions in saline shallow lakes decrease with salinity, which increases towards the warmest months due to the evapoconcentration of salts, but they increase with highest slopes by temperature increasing, thus an antagonistic behavior interplays between these variables within the seasonal hydrological patterns in these lakes.

EFFECTS OF WARMING ON THE IMPORTANCE OF METHANE AS A POTENTIAL CARBON SOURCE FOR ZOOPLANKTON

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Methane has been demonstrated to serve as a carbon source for pelagic food webs. However, the environmental controls of this alternative carbon source in lakes with different mixing regime, trophic status, and plankton community structure are still poorly understood. Here we evaluated differences in fluxes and isotopic composition of CH4 and zooplankton of three lakes over a gradient of temperature regimes as a proxy for potential effects of global warming. Lakes Lichenskie and Mikorzynskie are heated by water discharged from cooling system of power plants. They are stratified with distinct thermocline and anoxic bottom waters. Their zooplankton is dominated by smaller forms (e.g, Daphna cucullata) during the summer. The Lake Budzislawskie (control cool lake) is stratified but without anoxia in the hypolimnion, and have zooplankton dominated by larger Daphnia longispina. The results revealed significant accumulation of CH4 in the lower water column of both heated lakes (up to 2.8 and 3.5µM in Lichenskie and Mikorzynskie) and strong gradients in the metalimnion (decrease from 1.5 to 0.2µM and from 2.3 to 0.4µM; respectively) hinting at active methane oxidation. In contrast, methane in the control lake accumulated in the metalimnion (max. 1.3µM). Together with methane productivity and distribution we will present the isotopic analyses of zooplankton and answer the question whether CH4 is an important carbon source for zooplankton. Our preliminary results show that warming and eutrophication can both enhance CH4 fluxes and its importance for pelagic food webs.
This research was funded by National Science Centre in Poland, project no. UMO-2015-18/M/NZ8/00119.

SPATIAL AND TEMPORAL VARIATION OF CO2 EVASION FROM A HUMIC LAKE IN THE WEST OF IRELAND

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Assessing the impacts of directional climate change on ecosystem services and formulating appropriate adaptation and mitigation strategies is the greatest scientific challenge that we now face. Future climate conditions, particularly warmer temperatures and shifts in seasonal precipitation patterns, as have been predicted for Ireland as a result of global warming, are likely to drive changes in the quantity and composition of external organic carbon (OC) entering aquatic ecosystems. The role that lakes play in making, storing and mineralising OC can be substantial and is relevant to regional and global carbon budgets. Complete whole lake carbon budgets are very rare globally, and are, so far, non-existent for Ireland. However, over the last 15 years, considerable progress has been made on resolving the carbon budget of Lough Feeagh, an oligotrophic humic lake in the west of Ireland, primarily through the use of the long-term environmental monitoring data that are collected by the Marine Institute. One large data gap remains to be filled, that is, quantifying carbon dioxide evasion from the lake. Completing this work will result in a more comprehensive understanding of carbon cycling in peatland lakes, and will feed directly into estimates of greenhouse gas (GHG) emissions from freshwater lake systems, which will need to be considered in future national GHG emission inventories. Here we present initial data of carbon dioxide evasion from Lough Feeagh using high-resolution, in-lake instrumentation, in tandem with CO2 flux measurements using floating chambers.

METHANE EMISSIONS RELATED TO THE MANAGEMENT OF A PUMP-STORAGE HYDROPOWER RESERVOIR

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The dynamics of methane ebullition was measured in Schwarzenbach reservoir during the stratified season in 2016. The reservoir is located in the south west of Germany and is used for pump-storage hydropower generation. We compared the temporal change in methane ebullition with the temporal change in water level resulting from the reservoir management. We specifically focus on consequences of sub daily water level fluctuations resulting from the pump-storage operation for hydropower generation. The data time series includes three consecutive time periods with different modes of operation starting with pump-storage hydropower generation followed by a period without water turbination and back to pump-storage hydropower generation. The data suggests that ebullition increases with abrupt reductions in water level resulting from turbination of reservoir water. During time periods without rapid decrease in water level (no water turbination) ebullition is reduced. As the gas released by ebullition consists mainly of methane the pump-storage operation leads to increased methane emissions. The ebullition flux is however additionally influenced by long term water level changes with less ebullition from the same site at higher water levels than at low water levels.

FUNCTIONING OF BOREAL LAKES IN THE GLOBAL CARBON CYCLE

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Estimates of the global terrestrial carbon dioxide (CO2) sink depend on the magnitude of lateral dissolved inorganic carbon (DIC) export from terrestrial ecosystems to inland waters. These estimates can vary widely, depending on the lake functioning assumed. Depending on lake characteristics, lakes can function as active carbon transformers or passive carbon transporters. We developed a conceptual model to describe the different functioning of lakes in carbon transport along the land to ocean aquatic continuum (LOAC). Using this model we showed with global data that depending on the main lake function assumed, the lateral DIC export, and thereby the size of the terrestrial CO2 sink, can vary between 0.45 and 2.70 Pg C yr-1. To better understand the role of boreal lakes within our conceptual framework we analysed the development of phytoplankton biomass in 34 Swedish lakes over a period of 21 years. We found a significant increase in the median phytoplankton biomass, although phosphorous concentrations had decreased over the past 21 years. We also found that organic carbon concentrations were significantly increasing in these lakes, and that annual precipitation across Sweden had significantly increased. We conclude that the present observed physical and chemical water changes in the boreal zone fuel phytoplanktonic CO2 assimilation in lakes. This, in conjunction with earlier findings on increasing lake respiration under a warming climate, suggests that boreal lakes will become more active carbon transformers.

METHANE CONTENT IN ALPINE COW PASTURE STREAMS INCREASES WITH RESOURCE SUPPLY

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Carbon (C) content in alpine streams is generally low and in-stream heterotrophic metabolism is often subsidized by terrestrial deliveries. Most studies on carbon fluxes in alpine streams focus on ecosystem metabolism and evasion fluxes of carbon dioxide while very little work has been done on methane (CH4) fluxes in those ecosystems. Consequently, our understanding of CH4 dynamics and its drivers in alpine streams is poor at present. To better understand CH4 dynamics in low-carbon streams, we investigated surface and subsurface waters in 16 streams flowing through sub-alpine and alpine pastures in the Swiss Alps. Water samples were analyzed for CH4 and dissolved organic carbon (DOC) concentration, dissolved organic matter (DOM), nutrients, discharge, velocity, temperature, and oxygen. Our results suggest a strong influence of the supply and quantity of DOC and nutrients as well as of the supplied DOM quality on the CH4. CH4 concentrations in the surface water samples ranged from 0.08 to 12 umol L-1 (median = 0.274 umol L-1), which is close to the concentrations reported from lake surface waters. This is surprising given the low DOC concentrations (0.1 to 2 mg C L-1). Therefore, considering the strong reaeration owing to turbulence, alpine streams are likely a significant source of CH4 to the atmosphere and perhaps worth being considered for better constraining global C emissions.

AN ESTIMATE OF THE TOTAL ORGANIC CARBON STORED IN POND SEDIMENTS IN GREAT BRITAIN.

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The role of ponds within the carbon cycle has received increasing interest. Substantial global coverage combined with ecosystem function rates disproportionately intense for their size makes them significant carbon cyclers. However, their potential in global biogeochemical cycles is often overlooked, constraining both small and global carbon budgets. This research provides the first estimate of pond sediment carbon stocks across Great Britain.

Carbon stocks were surveyed in fifty-five ponds from four regions of Britain, selected for their diverse range of pond types. Forty ponds were located in northeast England comprising four broad pond types: dune-slack ponds; arable field ponds; pasture field ponds; and classically vegetated ponds. Furthermore, fifteen ponds were sampled from three biogeographically diverse regions of England: lowland peat mire, Yorkshire; post-glacial pingo-ponds, Norfolk; and lowland heathland ponds, Cornwall. A total of 91 cores were collected, ranging 20-30 cm, and analysed a 1 cm intervals.

Large variation in measures of percentage carbon were found among sediments, both within and among ponds. However, when quantified in terms of carbon stock, (kg-1 C m-2), markedly less difference was observed with little significant difference within and among ponds, allowing for a standard unit of C stock within pond sediments to be estimated. Combined with estimates on the area of pond habitat across Great Britain, as given in the Countryside Survey 2007, a conservative estimate of sediment carbon stocks is provided. Given the similarity of pond habitats across temperate regions of Europe and North America there are significant wider applications for these initial results.

SPATIO-TEMPORAL PATTERNS IN METHANE EMISSIONS FROM TEMPERATE URBAN FRESH WATERS

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Methane (CH4) released from fresh waters accounts for 1.4–13.2% of the global emissions of this potent greenhouse gas (GHG). Motivated by the importance of CH4 for climate change, drivers of CH4 emissions from water bodies have been studied in all climatic regions. However, the focus has been almost invariably on natural ecosystems, so that little is known about CH4 dynamics in urban fresh waters, where environmental conditions could be particularly conducive to CH4 formation. Here we report on CH4 emissions from a total of 32 freshwater bodies covering the metropolitan area of Berlin, Germany. They represent surface waters typically affected by multiple stressors, including alterations of hydrological regimes and morphology as well as water and sediment pollution by nutrients and micropollutants. Four types of water bodies (lakes, ponds, rivers and streams/ditches) differing in the degree of human modification were repeatedly studied over an entire year to estimate Berlin´s aquatic CH4 footprint. Our tentative analysis of data from spring and summer 2016 suggests considerable spatial and seasonal variation in CH4 emissions. Variation was highest in lakes and rivers, where emissions appear to be influenced by the degree of human modification, whereas ponds and ditches had the highest average emission rates (approximately 214 mg CH4 m-2 d-1 in summer). Our results on CH4 emissions from surface waters in the city of Berlin support the notion that considering urban areas is important when assessing aquatic GHG emissions at global scale .

HYDRO ACOUSTIC GAS VOID DETECTION VIA INTERNAL SHEAR STRESS MEASUREMENTS IN THE SEDIMENT

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Methane is after CO2 the most important greenhouse gas, it´s flux to the atmosphere via diffusion or ebullition from the sediment in impounded rivers or reservoirs is a widely discussed topic today.
The detection of methane production over extended areas represents still a challenging task. Hydro acoustic tools like lakebed classification seem to be able to detect the spatial distribution of gas voids in the in the sediment. Compared to in-situ sediment sampling they can be highly time and cost efficient. However, the exact definition of gas volumes in various types of sediments is complicated and challenging. Groundtruthing samples, like sediment cores are always needed and often lead to unreliable results, since the free gas in the sediment becomes mobilized during the penetration of the coring device.
To avoid high costs, the mobilization of gas and core sampling efforts, a combination of a dynamic penetrometer (Gravy Probe, dotOcean) with hydro acoustic measurements was conducted. Two different echosounders (EA 400: linear 200 kHz, 38 kHz and SES 2000 compact: parametric sub-bottom profiler 100 kHz, 6 kHz) were used. Core samples were taken for groundtruthing. The study sites were two German reservoirs Schwarzenbachtalperre and Urfttalsperre. The presence of the voids in the sediments is clearly indicated by a strong decrease in cone penetration resistance, from which the exact position of the gassy layer can be derived. The shear stress and the calculated bulk density were correlated with reflectivity patterns and allowed for mapping of gas voids in the sediment.
This new technique is very promising in terms of methane production quantification over extended areas.

FALL FAVORS GAS EBULLITION IN A TEMPERATE STORAGE RESERVOIR

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Ebullitive emissions of greenhouse gases have become an increasingly important gas flux from river impoundments to the atmosphere, contributing to the global carbon budget and global warming. The dynamics of gas bubbling, however, varies with spatial and temporal scales, thereby perplexing understanding and quantification of such a process. A water storage canyon-shaped reservoir (2.1 km2) in the temperate zone was investigated using hydroacoustic surveillance and gas traps during two consecutive years. The observed gas bubbles ranged from 2 mm to 7 mm in equivalent diameter, primarily containing methane (on average 65%) with a negligible amount of carbon dioxide (0.1%). Seasonally, ebullitive fluxes depended upon the time period, i.e. less than 2 mL m-2 d-1 in spring, but exponentially increasing from the middle of summer to the highest values reached in late fall (~70 mL m-2 d-1) in both the years investigated. In the beginning of winter, fluxes dropped back to a low level. Spatially, the longitudinal distribution in ebullition was related to the proximity of the river inflow, declining towards the dam. In fall, however, bubbling areas expanded further into greater depths, covering almost two thirds of the reservoir's length, likely following annual thermal maximum of sediments. The study indicates that seasonality significantly determines gas ebullitive fluxes in the reservoir of the temperate zone.

EUTROPHICATION ENHANCING METHANE EMISSION FROM LAKE: A CASE STUDY IN LAKE CHAOHU, CHINA

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Global warming and eutrophication are two world widely concerned environmental problems. Methane is the second important greenhouse gas, and lake has been proven as a quite important natural source of methane emission. More methane may emit from eutrophic lake due to the higher organic matter deposition in the lake sediment. Lake Chaohu is a shallow and eutrophic lake in eastern China (N31°25′~31°43′, E117°16′~117°05′), with an area of 770 km2 and a mean depth of 2.7 m, and the northwest bay is the most eutrophic area of this lake. A year-round field study was carried out with 20 sites to examine methane distribution and transportation in this eutrophic lake. Samples from the different water and sediment depth was collected using headspace bottle, and methane content was measured by gas chromatography using a flame ionization detector. The potential methane production in the sediment was examined by an indoor incubation experiment. Methane flux from sediment to the overlying water, and methane emission from surface to the air were calculated. The results indicates that more methane accumulated in the northwestern bay of this lake, and higher methane emission rate was also found at this area. More methane content and the higher potential methane production was also found at northwest bay compared to the sediment from the east area of this lake. All results indicate eutrophication enhancing more methane production and emission from Lake Chaohu.

MONITORING INVASIVE CRAYFISH USING ENVIRONMENTAL DNA (EDNA): A LAB AND FIELD EVALUATION

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Environmental DNA (eDNA) techniques are becoming increasingly popular in conservation and invasion biology, especially for monitoring and early detection of rare, endangered or invasive species. An exponential increase in divergent methods regarding eDNA collection and analysis has been observed, which leads to mixed success in detection efficiency in studies on aquatic invertebrates. In this study, we tested and compared three DNA extraction methods using crayfish as model species. Based on existing and newly developed primers we were able to identify two invasive crayfish species (Procambarus clarkii and Orconectes limosus) from tissue and filtered eDNA samples from water of aquaria kept in the laboratory as well as water from natural ponds. Both species could be positively identified in field and laboratory samples, though effectiveness differed greatly. Results in our study seemed to be highly dependent on primer choice, DNA extraction method, chosen species, and the type of sample (tissue or filter). Our results showed that the MasterPure extraction kit consistently provided the most reliable results for tissue and for filtered eDNA samples for both species. The results are promising, but also highlight the necessity for a standardized protocol for each step of the eDNA process.

ON THE WAY TO IMPLEMENTATION OF ECOGENOMIC INDICES FOR RIVER BIOMONITORING: A FRENCH PROGRESS REPORT FOR DIATOMS

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The best picture of an ecosystem health is provided by the biological characteristics of the communities that live in it, in comparison to a reference state, free from anthropogenic pressures. These are the founding ideas of the WFD. In France, the long-standing efforts to monitor water quality have led to the development of bioassessment methods based on diatoms since the 1980s. These methods have then been brought into compatibility with the WFD for freshwater.

The simultaneous development of DNA barcoding and of high-throughput DNA sequencing (HTS) has led to the emergence of the idea of using such approaches to characterize environmental communities. Since the 2010s, “proof of concept” as well as environmental scaling-up have shown their potential to evaluate health status of rivers. Tools and tests have been progressively released for applying diatom DNA metabarcoding in the context of bioassessement. Although many technical issues have been enlightened for diatoms (DNA barcode, DNA extraction, Reference library…), many are still pending (DNA preservation, HTS technology, sequencing depth, quantification…).

Different indicators can then be produced: WFD-friendly ones (community structure at species level, comparison to reference state), or indicators better exploiting the big data from HTS. However, taxonomical and ecological expertise of current stakeholders and comparability to historical data should not be left out when implementing these indicators. Going towards WFD implementation of DNA-based diatom indicators will also require standardized procedures (CEN standards) and collective implementation with the numerous stakeholders (SMEs, academics, environmental managers…) at national and European levels.

SYNAQUA: A FRENCH-SWISS PROGRAM TO MODERNIZE THE ENVIRONMENTAL BIOMONITORING OF LAKE GENEVA AND TRANSBOUNDARY RIVERS

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Rivers and lakes play a major role in the environment by providing not only habitat for fauna and flora, but also improving the landscape and therefore the quality of life. The effectiveness of environmental protection measures rests on the early and precise identification of pressure points, which should be facilitated by environmental genomics. To implement measures to preserve or restore aquatic areas, the SYNAQUA project proposes to use the genetic tools based on the recognition of bio-indicator organisms present in the aquatic environment directly from their DNA. The method of environmental DNA analysis, will be tested by Swiss and French scientists in collaboration with public and private stakeholders on two groups of bioindicators commonly used for water quality assessment: diatoms and oligochaetes.

The aim is to bring together scientists, environment managers as well as public and private partners in Switzerland and France to develop and apply this DNA-based broadband approach to biomonitoring of regional aquatic ecosystems. Collaboration between public and private stakeholders will help to develop a robust and reliable tool that is tailored to their needs and will strengthen the current practice of environmental diagnosis. The innovative tools that will be developed in synergy in France and Switzerland should make it possible to respond to the need for better monitoring and protection of the regional heritage of aquatic environments in a rapidly changing area subject to multiple pressures.

USING DNA METABARCODING FOR STREAM ECOSYSTEM ASSESSMENTS: OPPORTUNITIES AND CHALLENGES

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Accurate assessments of macrozoobenthic community composition are essential to monitor stream health. Unfortunately, morphological identification of macrozoobenthic indicator taxa at larval stages is often difficult, yet DNA barcoding has emerged as a powerful alternative allowing quick and reliable identifications.

Here, we applied DNA metabarcoding using four different primer sets to identify macroinvertebrates from 18 samples obtained from the Finnish stream monitoring programme. When compared with morphological identification, metabarcoding performed better across all samples with detecting 57% more taxa on average. All four primer sets, developed specifically for freshwater macrozoobenthos, performed equally good. In addition, we showed that sample presorting into size classes increases taxa detection rates and decreases the already low sequencing costs of about 110 € per sample up to 5 fold. Finally, we explored modifications of the classical metabarcoding protocol to generate data with haplotype level accuracy.

Despite these advantages there are several remaining challenges, e.g. gaps and/or incorrect entries in reference databases as well as a lack of convergence in laboratory and bioinformatic pipelines. While the latter aspects can be solved by molecular ecologists and bioinformatics, there is a growing need to team-up with expert taxonomists and field biologists to describe newly identified species, assign biological traits and taxonomically curate the still error-prone DNA barcoding databases. While we here could show that metabarcoding is a suitable alternative to morphology-based identification of macroinvertebrates, the full potential of DNA-based methods can only be unlocked in an interdisciplinary network of researchers as well as of stakeholders.

FROM RIVERSCAPES TO LAB: DELINEATING MONITORING NETWORKS OF BIOTIC INDICES USING NEW GENETIC TOOLS UNDER MULTIPLE STRESSORS

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Environmental DNA (eDNA) and metabarcoding are potentially useful tools for monitoring water ecological status and detect rare species, including threatened and recently introduced species. While it is now clear these tools have the ability to generate important data to inform managers, its widespread application has been hindered by the lack of standardised approaches, from field sample collection, to lab and bioinformatics protocols. This includes knowing how DNA traces vary under different environmental conditions and how it varies according to multiple stressors, among others.

Here we aim to illustrate the best workflow to delineate an optimized monitoring network of sites for accessing water ecological status using the new genetic tools. We used macroinvertebrates to build biotic indexes. We also used watercourses of Douro Basin (Spain and Portugal) as a case study because it includes a variety of stressors, climates, and population density. Firstly we gathered datasets from environmental conditions and multiple stressors, including regional and global available datasets (eg Global Human Footprint). Secondly we used GIS and ordination techniques to represent the environmental and multiple stressors gradients of the Douro Basin, and map the selected sampling sites that represent the whole gradients. We obtained the network of monitoring sampling sites for macroinvertebrates that cover the gradients of human impacts and environmental conditions. Finally we discuss the next steps for the workflow, including how to validate the reliability and sensitivity of biotic indexes to respond to gradients of stressors while accounting the environmental conditions.

INBIO BARCODING INITIATIVE: BUILDING A REFERENCE DATABASE FOR FRESHWATER INSECTS USING NEXT-GENERATION SEQUENCING

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DNA barcoding enables the molecular identification of organisms and is expected to have high applicability for biodiversity monitoring. The extent of its application is however dependent upon the existence of comprehensive reference collections and corresponding DNA sequence databases. Unfortunately, these are still lacking for many invertebrate groups, especially from biodiversity hotspots, like the Mediterranean basin. In this context, InBIO is developing a DNA barcoding database focusing on Iberian aquatic insects. More than 750 specimens of seven insect orders were already analysed: Coleoptera, Ephemeroptera, Hemiptera, Megaloptera, Odonata, Plecoptera and Trichoptera. Genomic DNA was extracted and the mitochondrial COI gene fragment (658 bp) was amplified in two overlapping fragments. DNA barcodes were sequenced using high-throughput sequencing (Illumina). Our results exhibited a scenario that illustrates some of the challenges posed by insect identification using DNA barcoding. While many species could be easily identified using the targeted DNA fragment, some cases of low divergence between species were detected. Cryptic diversity was found in several situations, mostly when comparing specimens from Iberia and central Europe, but in some circumstances, even within Iberian Peninsula specimens. Furthermore, by using high-throughput sequencing techniques nuclear copies of COI fragments were recovered in some species. These sequences are also likely to be

detected in eDNA metabarcoding studies, and should therefore be documented and data-based. We expect InBIO's reference collection to become a fundamental tool for long-term and large-scale monitoring of aquatic freshwater ecosystems in the Iberian Peninsula.

METACOMMUNITY ORGANIZATION IN SPATIALLY CONSTRAINED, DYNAMIC SYSTEMS : A MOLECULAR PERSPECTIVE

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The metacommunity framework has become a paradigm for community ecologists. Not only local processes, such as habitat filtering and biotic interactions, but also dispersal, are recognized to control species distribution among localities of a given ecosystem. This framework has generated a rich conceptual and empirical literature in the past decade, essentially in lattice-type, terrestrial systems. For stream ecologists, the application of this framework is complicated by the dendritic nature of river networks and how this constrains the movements of organisms. Moreover, when using aquatic invertebrates as a biological model, limitations associated with morphological identification, such as the coarse resolution for ubiquitous and abundant groups like dipterans, oligochets, water mites, reduce our capacity to understand metacommunity organization. Ignoring the phylogenetic relationships between species can also lead to biased estimates of betadiversity.

These two limitations can be overcome using molecular identification through metabarcoding approaches, which allow assessing betadiversity at the molecular scale and calculating a DNA-based index: phylobetadiversity. However, methodological developments are needed and the assessment of metabarcoding relevance for aquatic invertebrates in a metacommunity perspective is lacking.

In this project, we address invertebrate metacommunity organization across 540 sites from 18 headwater streams in France using morphological and molecular identifications. We notably predict the role of dispersal processes to be more important than previously thought, due to dynamic nature of headwater streams. As a first step, we present here the initial conceptual and methodological developments and perspectives

DNAQUA-NET: DEVELOPING NEW GENETIC TOOLS FOR BIOASSESSMENT AND -MONITORING OF AQUATIC ECOSYSTEMS IN EUROPE

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The protection, preservation and restoration of aquatic ecosystems and their functions is of global importance. For European states it became legally binding mainly through the EU-Water Framework Directive (WFD). In order to assess the ecological status of a given water body, aquatic biodiversity data are obtained and compared to a reference water body. The quantified mismatch thus obtained determines the extent of potential management actions. The current approach to biodiversity assessment is based on morpho-taxonomy. This approach has many drawback such as being time consuming, limited in temporal and spatial resolution, and error-prone due to variation of individual taxonomic expertise of the analysts. Novel genomic tools can overcome many of the aforesaid problems and could complement or even replace traditional bioassessment. Yet, a plethora of approaches are independently developed in different institutions, thereby hampering any concerted routine application. The goal of this Action is to nucleate a group of researchers across disciplines with the task to identify gold-standard genomic tools and novel eco-genomic indices for routine application for biodiversity assessments of European water bodies. Furthermore, DNAqua-Net will provide a platform for training of the next generation of European researchers preparing them for the new technologies. Jointly with water managers, politicians and other stakeholders, the group will develop a conceptual framework for the standard application of eco-genomic tools as part of legally binding assessments.

METAGENOMIC ANALYSIS OF MACROINVERTEBRATES ALONG THE LLOBREGAT RIVER (NE-IBERIAN PENINSULA) AND ITS USE FOR BIOMONITORING

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The advent of the massive parallel sequencing technologies have empowered DNA barcoding tools to automatize species identification for an entire community. Metagenomic data provide cost and time efficient, fine-scale taxonomical resolution, which will facilitate applying biological indices to determine ecosystem health under the EU-Water Framework Directive (WFD). In this study, we compared estimates of the ecological status using traditional morpho-taxonomy against high-throughput DNA sequencing of (1) bulk sampling, (2) eDNA (water samples) and (3) invertebrate drift sampling (intervals of 1 hour). We sampled five sites along the well-studied Mediterranean Llobregat river (156 km length) from headwaters to river mouth. The sites included (1) a pristine headwater reach; (2) an upstream reach located downstream of a big reservoir; (3) a mid-river reach surrounded by an urban and agricultural landscape; (4) a reach located downstream of salt mining site; and (5) a lowland reach. In this talk, we provide details of the sampling techniques, sample pre-processing, DNA extraction, genetic markers used and bioinformatic pipelines for sequence filtering, delimitation of MOTUs and taxonomic assignment. Our results confirm the finer taxonomic resolution obtained by metagenomic analysis and therefore the usefulness of the method to determine macroinvertebrate biodiversity. We provide new insights on the potential of high-throughput DNA sequencing for replacing the traditional bioassessment tools used in biomonitoring programs under the WFD. Finally, the importance to establish new protocols to assess ecological health of water bodies using metagenomic analysis is highlighted.

LANDSCAPE FEATURES AND SPECIES' INTRINSIC TRAITS SHAPE THE CONTEMPORARY PATTERNS OF GENETIC DIVERSITY OF PORTUGUESE ENDEMIC CYPRINIDS

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Over 68% of the native Iberian cyprinid species are currently highly endangered. Management and conservation actions should ideally be planned taking into account the genetic diversity shown by different populations of a given threatened species, reliable taxonomical identifications (including the detection of cryptic hybrids) and contemporary drivers of gene pool depletion. In this context, a broad genetic survey was conducted in the Portuguese hydrographical network (all the 34 river basins and 47 sub-basins), covering a total of 188 populations belonging to 16 cyprinid species of Squalius, Luciobarbus, Achondrostoma, Iberochondrostoma, Anaecypris and Pseudochondrostoma. The analysis of over 3,600 cytochrome b gene sequences revealed differences among populations from the same species and between species with identical distribution areas. Factors shaping the contemporary patterns of genetic diversity were explored and the results revealed the role of latitude, inter-basin connectivity, migratory behaviour, species maximum size, species range and other species intrinsic traits in determining the genetic diversity of sampled populations. Species intrinsic traits, maximum size attained, inter-basin connectivity and latitude explained over 30% of the haplotype diversity variance and, generally, the levels of diversity were significantly higher for smaller sized species, from connected and southerly river basins. Thus, contemporary determinants of genetic diversity (species' intrinsic traits and landscape features) are likely more important than historical factors, with strong implications for species conservation, in a context of climate change and highly disturbed fluvial habitats.

DNA BARCODING OF AQUATIC MACROINVERTEBRATE FAUNA OF SLOVAKIA – FIRST INSIGHT

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Water quality monitoring and biodiversity assessment of the European fresh waters is currently realized in terms of the EU-Water Framework Directive (WFD, 2000/60/EC) and it is based on morphological identification of freshwater taxa. Novel approaches and initiatives (e.g. DNAqua-Net) lead to future implementation of the modern genomic tools in bioassessment of European water bodies. Essential for achieving this milestone is existence of comprehensive databases of DNA data for freshwater taxa present in European waters. Reference barcode libraries of all main freshwater groups of organisms are built within several national DNA-barcoding campaigns. But, there are still countries where such activities are only starting or are not at all.
In terms of accession to the EU and implementation of WFD, first detailed check-list of all macroinvertebrate taxa recorded from Slovak Republic was elaborated in 2003. The check-list comprises 1700 macroinvertebrate species present in Slovakia, and after several years of monitoring surface waters, following the WFD methodology, cca 50 additional species were included. Presently, together with sporadic new records and unknown cryptic species, there could be more than 2000 macroinvertebrate taxa present in the Slovak fresh waters.
However, the coverage of the Slovak aquatic fauna by DNA barcodes is very poor. Within the BOLD (The Barcode of Life Datasystem) database, there are only 165 public records of aquatic invertebrate taxa collected in Slovakia covering up to 60 OTUs (end of 2016), and bulk of them (95 %) represents older records mined from the GeneBank (NCBI). Considering these gaps and following the goals of the WG1 ("DNA Barcode Reference Databases") of the "DNAqua-Net" COST Action, since 2016 our laboratory started to built reference barcode library of Slovak Aquatic Fauna. Presently we focus on the Slovak fauna of aquatic beetles and caddisflies. Primarily we started with collecting data from the alpine lakes and from the carstic springs, and here we present the preliminary data.
This work is supported by the EU COST Action CA15219 "DNAqua-Net" (Developing new genetic tools for bioassessment of aquatic ecosystems in Europe) and projects VEGA 2/0030/17 and 1/0255/15.

SPATIAL ARRANGEMENT OF EU HABITATS IN LOWLAND WETLANDS: CONTRIBUTION OF NATURA 2000 TO BIODIVERSITY IN A HYPER-EXPLOITED AGRICULTURAL LANDSCAPE

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Wetlands are among the most impacted ecosystems worldwide and the species they support among the most threatened taxa. This is especially true in agricultural landscape, where wetlands play multiple key processes for local biodiversity and ecosystem functioning. A case example is the Po plain (Northern Italy), one of the most productive plains in the northern Hemisphere. Here, inland wetlands cover less than 5% of the pristine surfaces. Focusing on a complex of 22 Natura 2000 sites of the Emilia-Romagna region, we explored the spatial patterns of European Union (EU) habitats of conservation concern to assess the effectiveness of local programs for nature conservation on aquatic taxa and wetland habitats. A total of 271 wetlands were characterized with the aim to identify the role played by geography, hydrology, connectivity, land use and climate in determining the spatial patterns of habitat richness. Additionally, we tested the relationships between habitats, community composition and species richness of waterbirds and other taxa of community interest. Site and water surface area, as well as connectivity were the major drivers of habitat diversity, whereas land use in the surroundings had scarce effect. Our results showed a good concordance between assemblage patterns of both habitats and taxonomic groups that may be related to the complexity of local niche availability. The present results also suggest the need to improve the hydrological connectivity of wetlands, favouring multiple submerging/emerging phases.

UNDERSTANDING MULTIPLE STRESSOR INTERACTIONS AT THE BASIN LEVEL BY INTEGRATING PROCESS-BASED AND EMPIRICAL MODELLING

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River systems are among the most degraded systems in the world. Stressors affecting these systems are multiple and diverse in nature and tend not to act independently, they interact. This interaction may be expressed in more than one way, it can be additive, synergistic or antagonistic. When studying the effect of stressor combination in river networks, their unique hierarchical dendritic nature needs to be accounted for. Because a given pressure affecting a given segment is not spatially limited as it most often extends its impact to the downstream river network. To understand how different pressures act in combination at the basin level, a case study (Sorraia river basin – Portugal) was used to test a framework that combines process-based (SWAT – Soil and Water Assessment Tool) and empirical modelling (GLM - General Linear Models and CART - Classification And Regression Trees). As the ecological status of rivers is influenced not only by what happens within the river but also by the surrounding environment (e.g. upstream drainage area), several climatic, hydrologic, land use, geomorphologic and pressure variables were selected as explanatory variables. The results show that several pressures interact to change the ecological status of surface waters. This framework can be further used to predict how future climate changes will affect ecological status, and to test the effectiveness of plans of measures to ameliorate the response to impacts of stressor interaction. This methodology proved to be helpful for an effective and resource efficient management and conservation planning of river basins.

IDENTIFYING FRESHWATER PROTECTED AREAS IN SPAIN: BRIDGING THE GAP BETWEEN SOCIAL AND SCIENTIFIC CRITERIA

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In 2005 the Spanish authorities declared a set of riverine protected areas with the aim of "preserving those rivers subjected to low or none human pressure". This resulted in a network of a reduced number of protected river reaches mainly located in headwater streams with high ecological status. However, several questions arise: what are these areas meant to preserve? Will they achieve its conservation goals? These questions are much easier to answer when systematic conservation-planning tools (SCPT) are applied. We applied these tools in the Ebro River basin (Spain) due to its heterogeneity in terms of environmental conditions and river types, the availability of public data and the multiple social conflicts that exist. Our aim was to compare the current network of protected areas with a network designed following objective criteria using SCPT. Firstly, we conducted workshops with a wide variety of actors (e.g. government agencies, NGOs, researchers) to identify a broad set of conservation goals (i.e. what should be protected?) that reflect the needs and interests of all actors. Secondly, we defined our planning units and modelled the spatial distribution of biodiversity (i.e. algae, macrophytes, macroinvertebrates and fish) throughout the catchment using environmental data, land-use attributes and other relevant topographical and climatic variables as predictors. Finally, we identified priority areas that met our conservation goals using complementary algorithms in the free software MARXAN. In this presentation we will use our results to discuss key questions concerning freshwater conservation: what do we need to preserve? Are scientists aligned with the rest of society in their concerns? How do different stakeholders understand rivers and their associated goods and services? Answering these questions is urgently needed if we want to slow down the accelerating freshwater species extinction rate.

OPTIMIZING RIVER AREA PROTECTION AND RIVER BARRIER REMOVAL DECISIONS: BALANCING BIOLOGICAL INTEGRITY WITH ECOSYSTEM SEVICES DELIVERY

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Conservation planners are often faced with tradeoffs that arise from the desire to preserve biological integrity (BI), on the one hand, and the need to maintain the delivery of ecosystem services (ES), on the other. This is especially true in the context of river catchment management, where the protection of aquatic biodiversity must frequently compete with maintaining a range of important ecosystem services (e.g., water extraction, hydropower generation, and recreation). Spatial prioritization methods offer an ideal tool for balancing BI protection with ES provisioning. Indeed, various approaches have been proposed in the literature for designing protected river area networks. While a few studies have taken into consideration the importance of longitudinal connectivity to the long-term persistence of BI, this has usually been done in a rather simplified manner via measures of proximity among protected areas. What is missing from the existing literature on systematic river protection planning is the impact that physical in-stream barriers (e.g., dams, road crossings, and falls) have on aquatic organism dispersal and persistence and the potential to directly mitigate them. To this end, we present a novel river area protection and barrier removal decision planning model to optimize BI protection/connectivity and ES delivery goals. As part of a case study, we apply the model to a set of Hungarian river catchment areas. Empirical findings highlight the inherent tradeoffs between BI and ES as well as the significant BI gains that can be achieved from barrier removal.

ACCOUNTING FOR STREAM NETWORK STRUCTURE WHEN PREDICTING THE SPREAD OF INVASIVE CRAYFISHES

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Although species distribution models (SDMs) have been increasingly used to inform managers where to put conservation actions, few approaches to date account for the influence of the spatial structure of stream networks on species distribution. This may be of particular importance for early detection of invasive species, whose distributions are strongly driven by dispersal and establishment processes.
Here we examine the relative importance of spatial structure versus environmental conditions in predicting crayfish distributions, and the value of considering in-stream versus Euclidian distances to account for spatial dependencies. We focus on two invasive crayfish (Procambarus clarkii and Pacifastascus leniusculus) in the Sabor River watershed (SABOR-LTER project, Portugal). We modelled the presence/absence of each species with GLMM using environmental predictors (i.e. slope, elevation and stream order) and spatially autocorrelated random variables based on Euclidean or in-stream distances. For each species, we built three sets of SDMs including: (i) environmental, (ii) spatial, and (ii) environmental and spatial predictors. As expected, the distributions of both species displayed strong spatial dependence, particularly in downstream direction. Models accounting for spatial structure using the full covariance mixture-model approach predicted crayfish presences/absences better than models including environmental predictors or Euclidian distances.
We recommend accounting for the spatial structure of stream networks when modelling distribution of freshwater invaders to improve SDMs accuracy, and thereby the spatial processes underlying biological invasions (e.g. dispersal and establishment). This study provides baseline approach and outputs to understand long term changes in the distribution of invasive species in the SABOR LTER site.

EVALUATION OF HABITAT PROTECTION UNDER THE EUROPEAN NATURA 2000 CONSERVATION SCHEME

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Protected areas are a key tool to halt the loss of biodiversity worldwide. The world's largest network of protected areas - Natura 2000 - has been implemented to preserve species and habitats in Europe. Assessments on the effectiveness of Natura 2000 have mainly focused on species, while almost nothing is known about the protection status of habitats. I will present an approach to evaluate the coverage of Natura 2000 habitats and consecutively fill the gaps in habitat coverage using a cost-effective optimisation approach. We exemplified the approach for Germany, which is one of the most densely populated countries in Europe, and, hence, a challenge for establishing effective conservation areas. To be able to evaluate the habitat coverage, we specified the probability of habitat occurrence at 30 km^2 quadrants by combining habitat type maps available at a coarse spatial scale (120 km^2 quadrants) but with high thematic resolution (habitat classifications) with a habitat class map that offers a fine spatial but low thematic resolution. To verify the maps, we used occurrence data of habitat type characteristic plant species per 30 km^2 quadrants. We found that, although Natura 2000 covers all the habitats listed, naturally frequent habitats, like 'old acidophilous oak woods', are underrepresented compared to infrequent habitats like 'humid dune slacks'. Furthermore, Natura 2000 does not comprise the most effective set of protected areas to represent habitats proportionally. We argue that, without a specific area target for habitats, a balanced representation of habitats in Natura 2000 is not possible.

FORGOTTEN GIANTS: THE FALL OF FRESHWATER MEGAFAUNA AND IMPLICATIONS FOR CONSERVATION

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Megafauna such as rhinos, tigers, and whales play vital ecological roles and are typically more vulnerable to ecosystem degradation and overexploitation than smaller animals. Meanwhile, they have raised attention due to human fascination with large animals. Contrarily to megafauna in terrestrial and marine realms, freshwater megafauna are neglected in both scientific research and conservation planning. At the same time, freshwaters are losing species faster than terrestrial and marine ecosystems. Up to date, knowledge of freshwater megafauna remains scattered. In order to get a comprehensive understanding of global freshwater megafauna, we compiled information about the contemporary distribution and conservation status of 207 megafauna species, including fishes, reptiles, mammals, and amphibians. Our analysis shows that global hotspots of freshwater megafauna are in the Amazon, Congo, Orinoco, Mekong and Ganges River basins. Generally, freshwater megafauna have a higher extinction risk than other freshwater species as they are facing multiple threats. For example, the Mekong and Ganges River basins harbor a diverse freshwater megafauna, while human pressures are especially high, with increasing trends since the early 1990s. The lack of consistent monitoring of freshwater megafauna populations is the first challenge that has to be tackled to develop and implement adequate and sustainable management strategies. Potential megafauna-based conservation strategies could benefit a broader range of less conspicuous freshwater species. Our results not only highlight the urgency of protecting freshwater megafauna, but also help raise public awareness of the freshwater biodiversity crisis.

CATCHMENT ZONING TO ENHANCE CO-BENEFITS AND MINIMISE TRADE-OFFS BETWEEN ECOSYSTEM SERVICES AND BIODIVERSITY CONSERVATION

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Integrating ecosystem services (ES) in landscape planning can help identify conservation opportunities by fostering co-benefits between biodiversity conservation and maintenance of regulation and cultural ecosystem services. However, the adequate integration of ES needs careful consideration of potential trade-offs especially between provisioning services and biodiversity conservation (e.g., the potentially negative consequences of agricultural water extraction within areas important for maintenance of biodiversity). These trade-offs have been overlooked to date, especially in freshwater systems. We used Marxan with Zones to identify priority areas for conservation of freshwater biodiversity (139 species of freshwater fish, turtles and waterbirds) and provision of freshwater ES in the Daly River, northern Australia. ES included groundwater provision for agriculture and recreational fisheries (assumed incompatible with conservation goals and a potential source of trade-offs), and carbon retention and flood prevention by riparian forests, and availability of perennial water (assumed compatible with biodiversity conservation and potential source of co-benefits). We prioritised the spatial allocation of (1) conservation management zones aiming to represent freshwater biodiversity patterns and compatible services to enhance co-benefits and a (2) trade-off zone, where access to provisioning ES could be granted. We found that potential trade-offs could be reduced up to 54% when using our approach compared to traditional planning where trade-offs are not explicitly addressed, while also enhancing co-benefits (up to 26%). Our novel approach could help address the increasingly complex catchment management context due to raise in demand for provisioning services and diminishing availability of resources, and management and planning challenges in other realms facing similar problems.

AFFORESTATION IN A CATCHMENT CONTEXT AND ITS USE AS GREEN INFRASTRUCTURE

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More than 386000 km2 of agricultural land was afforested in Europe during the last two centuries. In particular, Spain is the country where afforestation has been more intensive, occupying a 12% of its territory and becoming one of the most important agent of change of land cover and species distribution. In the case of Spain, the majority of afforestation examples have a hydrological and soil protection target, however, there is controversy in relation to the benefits of their extensive and indiscriminate use. Nowadays, Green Infrastructure networks are being proposed as a cost-effective restoration approach for river ecosystems that can target multiple objectives such as conservation of biodiversity and ecosystem service delivery. However, evaluating the effectiveness of Green Infrastructure implementation on river restoration success will have to wait to a near future, as there are not many case-studies yet. Thus, in this study we review afforestation projects that have been implemented in Spain and we explore how they affect river ecosystems and catchment processes. Furthermore, we build a spatial database of the study cases in order to relate catchment land cover to its hydrological response. The results show that the success of the afforestation actions highly depends on the plantation design as well as the climatic, topographic and soil local conditions. Other alternatives to tree planting (e.g. rewilding) should be contemplated and combined in the implementation of Green Infrastructure networks. This will ensure the success, cost-effectiveness, and improvement of the conservation of biodiversity and ecosystem service delivery in a catchment context.

IN ORDER OF DISAPPEARANCE: MACROINVERTEBRATE COMMUNITY CHANGES ALONG AN EXPERIMENTAL STREAM DROUGHT GRADIENT

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Climate models forecast an increase in the frequency of severe, supraseasonal droughts, yet ecosystem impacts remain poorly understood. In particular, disturbance gradients that are needed to characterise ecological responses across critical physical habitat transitions (loss of longitudinal connectivity, streambed drying) have rarely been studied. We analysed macroinvertebrate community changes along a gradient of drought intensity, simulated across twenty-one experimental channels (mesocosms) which mimicked chalk stream headwaters. Responses to one year of drought disturbance varied among taxa, and four broad groups were distinguishable: (1) rheophilic caddisflies, herbivorous chironomids and worms were highly sensitive to moderate drought stress (loss of longitudinal connectivity); (2) standing water specialists (mosquitoes, riffle bugs) and predatory chironomids exploited longitudinal fragmentation but were sensitive to complete surface water loss, which favoured (3) a small number of semi-aquatic Diptera; and (4) a minority of taxa (primarily leeches and flatworms) maintained stable populations along the entire gradient. Despite highly nonlinear responses among many taxa, community level response to drought (total abundance, community structure) was broadly linear. However, the persistence of small populations of some taxa in dry streambed refugia negated any trend in richness. Some of these observations, such as the reversal of natural predator: prey ratios among chironomids as channels fragmented, suggest that small changes in streamflow could trigger abrupt shifts in food web dynamics.

RESPONSE OF PHYTOPLANKTON AND ZOOPLANKTON COMMUNITIES TO EXTREME TEMPERATURE AND NUTRIENT STRESSORS: A MESOCOSM EXPERIMENT

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Phytoplankton and zooplankton are short-lived organisms responding fast and directly to environmental fluctuations which make them useful indicators of deterioration in lake ecosystems to stressors. Due to climate change, extreme events including heat waves will be more common in the future and such changes also augment eutrophication, a problem lakes are already facing today. To understand the effects of temperature and nutrient stressors on phytoplankton taxonomic groups and size diversity we used 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 and zooplankton samples were identified, biovolumes and size diversity were calculated. Using also physico-chemical variables from the mesocosms, the effects of the extreme heat wave on the phytoplankton and communities and structure at contrasting nutrient and temperature levels will be discussed.

POTENTIALS AND LIMITATIONS TO STUDY PELAGIC ECOSYSTEMS IN LARGE-SCALE ENCLOSURE FACILITIES

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Many methodological approaches have been developed to understand and predict how ecosystems function, especially under climate- and human-induced pressures. These approaches range from theoretical to data-driven models, and from field observations to well-controlled laboratory experiments. However, large pelagic enclosure experiments that facilitate statistically sound experimental designs while capturing much of the complexity of aquatic ecosystems are strongly underrepresented. These features have potential to provide mechanistic insights into ecosystem processes that might not be achieved through other approaches such as long-term data acquisition or small-scale experiments with limited species pools. Although experiments on ecosystem-scale levels are powerful, designing and conducting them requires particular care and expertise to obtain meaningful results. Challenges to meet include controlling periphyton growth on enclosure walls and maintenance of natural physical conditions and higher trophic levels over extended periods. These potential problems diminish with increasing size of the experimental units, however, other challenges such as ensuring similar initial conditions and control of fish tend to increase. Moreover, pelagic enclosures, even of large facilities, can reflect natural conditions only to some extent. Knowledge of the specific limitations is hence critical when interpreting and extrapolating the experimental data. Repeated coordinated experiments in multiple facilities could mitigate these limitations and place the results in a broad spatio-temporal context, especially when backed by long-term observational data and a sound theoretical and modeling framework. Further, to gain global insights into aquatic ecosystem functioning it is necessary to build collaborations beyond classical borders, by connecting experimental science in rivers, lakes, estuaries and oceans.

THE EFFECT OF A FINE SEDIMENT PULSE ON INVERTEBRATE SURFACE, LONGITUDINAL AND VERTICAL DISTRIBUTIONS IN STREAM MESOCOSMS.

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The amount of fine sediment entering river systems has increased in the last century, and is recognised as a leading cause of ecological degradation and water quality impairment. However, the exact mechanisms driving this ecological impairment are not yet fully understood. Our study used twelve open-air flume mesocosms to identify the impact of a fine sediment pulse on bed sediments and the dispersal pathways (i.e. surface, longitudinal and vertical) of benthic and hyporheic invertebrates. We also identified the influence of substrate porosity and interstitial habitat availability on the response of benthic and hyporheic invertebrates to elevated fine sediment levels. The channel bed of each stream mesocosm was divided in to two sections: consisting of a fine substrate and a coarse substrate mix. The benthic and hyporheic invertebrate communities (at 5, 11 and 18 cm depths) in each mesocosm section were sampled before, during, immediately after, 30 days and 60 days after a fine sediment pulse. Invertebrate drift, sediment deposition, depth of oxygen penetration and water quality were also measured on each sampling occasion. Our preliminary results indicate that high levels of fine sediment lower substrate heterogeneity, and prompt increased dispersion from benthic sediments.

HOW DO PHYSICAL AND CHEMICAL COMBINED STRESSORS AFFECT SHORT-TERM DRIFT RESPONSE OF BENTHIC MACROINVERTEBRATES?

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Increasing human disturbance is exposing stream biota to a complex set of interacting stressors, re-shaping species distribution and abundance. Water scarcity is a key stressor in Mediterranean rivers, which interact with other common stressors resulting from anthropogenic activities, such as eutrophication and hypoxia.
In this study the single and combined effects of flow reduction and dissolved oxygen (DO) depletion on macroinvertebrate drift response were assessed in a short-term experience implemented in winter and spring. A factorial design of 2 flow velocity levels (Regular and Low) with 3 levels of DO depletion (Normoxia, Mild DO depletion and a Higher DO depletion) was performed in an experimental stream mesocosm.
Single stressors effects showed that macroinvertebrate drift ratio decreased with flow velocity reduction and increased with the higher DO depletion for both winter and spring experiments. Despite single stressors opposing effects in drift ratio, combined stressors interaction induced a positive synergistic effect for both seasons, but only in winter the drift ratio was different between the levels of DO depletion. Stressors interaction in winter seems to aggravate drift response when hypoxia is higher. In our study, water scarcity exacerbated oxygen depletion conditions translating into a greater drifting behaviour of invertebrates.

EXPLORING THE FUTURE OF WETLAND VEGETATION THROUGH SOIL SEED BANK MESOCOSM EXPERIMENTS

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Soil seed banks represent an important source of propagules for vegetation regeneration in a wide range of temporary wetlands, from large desert floodplains to coastal marshes. Even in many degraded systems, large, diverse and persistent soil seed banks can be present despite declines in the extant vegetation. The composition of wetland soil seed banks reflects historical vegetation dynamics and also provides an indication of possible future responses of vegetation to environmental change. Germination, establishment and growth of plants from wetland soil seed banks are sensitive to many easily manipulated factors including watering regime, water quality (e.g. salinity), temperature and light. Mesocosm experiments using wetland soil seed banks therefore provide a valuable opportunity to explore the effects of key drivers of vegetation change and assess the vulnerability of particular plant species, communities or ecosystems to numerous pressures and stressors. Here, I will present findings from a range of mesocosm experiments examining vegetation responses to major pressures (e.g. warming, hydrological change, sea level rise, clearing and grazing) of current concern in a variety of inland and coastal wetland systems in eastern Australia. In doing so, I will highlight the benefits of soil seed bank mesocosm experiments for understanding wetland vegetation dynamics and also discuss challenges associated with experimental design and limitations of the results. I will conclude by offering suggestions for future wetland soil seed bank mesocosm experiments, especially with regard to opportunities for linking ecosystem structure and function.

MULTIPLE STRESSORS IN IRISH AGRICULTURAL STREAMS: A MESOCOSM STUDY OF MACROINVERTEBRATE RESPONSES TO NUTRIENTS AND SEDIMENT

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Agricultural practices, resulting in the delivery of excessive nutrients and fine sediment, can have a negative impact on freshwater ecosystems. This study aimed to identify the singular and combined effects of these stressors on the macroinvertebrate communities of Irish streams.

In this study, nutrients and sediment were manipulated simultaneously in a 64-channel streamside mesocosm facility. Various nutrient (phosphorus + nitrogen, nitrogen, phosphorus, controls with no nutrient addition) and/or sediment (high, medium, low, controls with no sediment addition) levels were added to each of the mesocosms. There were four replicates of each of the 16 treatment combinations.

The experiment was run for 10 weeks (8 weeks of colonisation and 2 weeks of experimental manipulation) during autumn 2016. During the first 8 weeks macroinvertebrates and algae flowed into the system from the adjacent stream to colonise the channels. Sediment was added to the mesocosms on the first day of the experimental period and allowed to settle. Nutrients were continuously drip-fed into individual mesocosms throughout the two-week experimental period.

Macroinvertebrate drift was collected in each of the 64 mesocosms at 24 hours after stressor addition and every 48 hours thereafter. The entire contents of each mesocosm were collected on the final day of the experiment.

This study will shed light on how these agricultural stressors individually and interactively affect stream macroinvertebrate communities and help prioritise policy and mitigation measures for managing agricultural impacts on freshwaters in Ireland.

ARTIFICIAL STREAMS FOR EVALUATING THE RESILIENCE OF BENTHIC INVERTEBRATE COMMUNITIES TO DROUGHT IN ALPINE AREAS (FERSINA RIVER B

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Over the last decades, alpine streams have been shifting from permanent to temporary systems due to the combined effects of Global Change and human pressures, and droughts are at present one of the most relevant threats for these lotic ecosystems. However, the impacts of droughts on aquatic communities have been poorly assessed through field studies, because drying conditions in alpine areas are usually unpredictable and mixed with several co-occurring confounding factors.

The resilience of benthic invertebrates to two repeated drought events was investigated in artificial streams (20 m long, 30 cm wide and 30 cm deep) directly fed by a second-order, pristine alpine stream. We conducted two sets of simulations in summer 2016 to evaluate the role of in-stream refugia (i.e., pools) versus drift on the recovery pattern of macroinvertebrate communities to short-term droughts. Incoming drift was collected with drift nets positioned at the upstream inflow of the selected flumes. Standardized pools were built with plastic buckets buried flush to the sediment. Results show that droughts significantly reduced the diversity and structure of benthic invertebrate communities. The flumes affected by droughts experienced a drastic loss of taxa, especially Ephemeroptera, Plecoptera and Trichoptera, and a marked dominance of few generalist taxa.

We detected higher values of richness and diversity in flumes with in-stream pools but differences with flumes without pools were not statistically significant, apparently indicating that community recovery to drought in fast-flowing alpine streams may depend on factors other than refuge pools (e.g., drift from up-stream, hyporheic refuges).

MULTIPLE STRESSORS IMPACTING SHALLOW LAKES - A MESOCOSM APPROACH

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Lowland lakes are predicted to be vulnerable to climate warming and to the accompanying increase in the frequency of extreme rainfall events. In order to investigate how this combination of stressors is likely to affect lowland shallow lakes, 32 large-scale outdoor mesocosm tanks (1 m deep, 2 m diameter) located at CEH Lancaster (North West England), were utilised to examine the effects of warming (ambient, ambient + 4°C), two different nutrient levels (no addition, nitrate and phosphate addition) and simulated extreme rainfall events (addition of 1500 L water) on ecosystem production, plankton diversity and fish abundance. The mesocosm tanks were seeded with lake sediment and lake water which contained representative populations of phytoplankton; additional zooplankton and macroinvertebrates were collected with nets from the lake. In addition, four adult sticklebacks, two of each sex, were added to each mesocosm tank. High-frequency physicochemical data (temperature, dissolved oxygen and radiation) were automatically collected for each mesocosm using in-tank sondes connected to a logging network. During the experiment, regular sampling of biota (phytoplankton (chlorophyll a), periphyton, zooplankton, macroinvertebrates, macrophytes and fish) together with water chemistry analysis established the defining characteristics of each treatment. The experiment was continued for one year and was part of the MARS EU-funded Project.

ESTIMATES OF C/N STOICHIOMETRY AND N RETENTION OF FOUR MEDITERRANEAN WETLAND SPECIES SUBJECTED TO WATER INPUTS FROM AN EFFLUENT OF A WASTEWATER TREATMENT PLANT.

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Helophytes are aquatic plants adapted to high nitrogen (N) concentrations in water and unstable substrates; therefore, they are used as green filters in waste water treatment and as elements to stabilize river banks in stream restauration. To gain knowledge of the potential N retention capacity from stream water nutrients of helophytes, we studied the carbon (C)/N molar ratio for different helophyte species (Phragmites australis, Typha angustifolia, Scirpus holoschoenus and Iris pseudochorus), considering different compartments of the plants. Plants were grown during 10 months in triplicated 12 m channels under identical conditions in an outdoor mesocosm nursed with the effluent of a WWTP in Catalunya (NE Spain). The species were planted in winter 2015 and where grown with a sub-surface water flow. Results of two-way ANOVA show that plant compartment explained much higher variance than species of observed variation in C/N ratio. Leaves showed the lowest C/N (18,03 ± 0,99SE), as expected from photosynthetically active tissues with high protein contain. Differently, all roots had significantly higher C/N (33,77 ±2,49 SE) as expected from a plant compartments playing a more structural function. In terms of standing stock, N retention was maximum in I.pseudoachorus (0,88 g N m-2) during the time curse of the experiment, a 80 % of it being allocated in the belowground compartment. This figures account for retention of 10 % of the dissolved N flowing through the channels during this period. Our results suggest that the capacity of helophytes to retain dissolved N in highly N enriched environments is moderated and varies depending on the species considered.

CHANGES IN COMPETITION BETWEEN PERIPHYTON AND MACROPHYTES INDUCED BY BROWNIFICATION: A LARGE-SCALE ENCLOSURE EXPERIMENT

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Inputs of humic substances from terrestrial into aquatic ecosystems have been increasing during the past decades in many regions. This brownification of inland waters can provide additional resources and reduce light availability, thus affecting primary producers. However, effects on interactions between periphyton and macrophytes, which compete for light and nutrients, are still unknown. We tested the impacts of humic substances on submerged macrophytes and periphyton in a large-scale enclosure experiment at different levels of nutrient supply. A total of 21 fishless enclosures received single pulses of humic substances at three levels, crossed with seven levels of phosphorus and nitrogen. Submerged macrophytes (Potamogeton pectinatus) and artificial substrates for periphyton growth were exposed for four weeks at five different water depths.
Brownification (highest level) resulted in a significant decline of both, macrophyte and periphyton biomass in 1.5, 3 and 6 m depth. However, the relative response of periphyton biomass to brownification in 1.5 and 3 m depth was stronger than that of macrophytes relative to controls (macrophytes 53 and 60% decline versus periphyton 91 and 96%, respectively). As a consequence, shading of periphyton on macrophytes in shallower water was reduced and macrophytes gained in importance relative to periphyton. Overall, this lower shading by periphyton did not compensate the effects of reduced light supply in browner water and total (theoretical) benthic primary producer biomass decreased by about 50%. A brownification-induced shift from periphyton to macrophyte in shallow waters has potential implications for several ecosystem functions such as carbon and nutrient storage.

PARTITIONING DIETARY ENERGY SOURCES USING COMPOUND-SPECIFIC ISOTOPES: A MESOCOSM STUDY

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The delineation of trophic pathways in food webs is necessary for understanding the structure and flow of dietary energy between organisms. A better understanding of each energy pathway is also necessary for studying food webs in the context of anthropogenic stressors and environmental change. One such example is the transfer of industrial contaminants from the base of a food web to top predators in aquatic ecosystems. There has been considerable investigation into the factors that influence contaminant exposure in top predators; however, there is little agreement on the role of trophic pathways in transferring contaminants, due to the assumptions and limitations of stable isotope analysis – the most commonly used method in trophic magnification studies. Our study employs the novel method of compound-specific isotope analysis to trace dietary energy in trout using a mesocosm experiment. With this method, we show it is possible to more accurately partition different energy sources – such as benthic versus pelagic – in the omnivorous arctic char (Salvelinus alpinus). These findings provide insight into how trophic structure can affect contaminant exposure to top predators via energy flow. This method could also prove to be important for understanding how trophic interactions can change due to anthropogenic stressors in aquatic ecosystems. This enhanced understanding of trophic dynamics could also be used to better protect aquatic ecosystems in the face of environmental change.

STREAM ECOSYSTEM RECOVERY FROM A SIMULATED SUPRA-SEASONAL DROUGHT

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An increase in precipitation stochasticity is predicted under climate change and is likely to manifest in increased drought frequency and duration for many lotic freshwater systems. Recent experimental studies have highlighted that drying will have a deleterious impact on the structure and function of biological communities. However, our understanding of the long term resilience to drought and rewetting is limited to observational field survey and a small subset of ecosystem functions. Here we show how stream ecosystems respond to and recover from supraseasonal drought conditions simulated in a mesocosm experiment. We established a replicated gradient of drought intensity by manipulating water level and flow across stream mesocosms (n=21) over 12 months. At the end of the drought year we restored flow to pre-drought conditions and tracked recovery for a further 12 months. A suite of ecosystem functions (n = 8) were recorded during both periods and used to create a compound measure of multifunctionality (MF). We found that drought intensification led to a progressive attrition of MF as functions were eroded sequentially by worsening drought with several functions (e.g. GPP and algal production) surprisingly sensitive to low-intensity drought. For the recovery, macroinvertebrate associated functions (e.g. secondary production and leaf litter processing) were resilient and recovered rapidly. However, MF in drought impacted channels only partially recovered; primarily due to a lack of recovery by submerged macrophytes. Our research suggests relatively small changes in habitat conditions can yield large changes in functioning that can persist for a considerable length of time post-drought.

DROUGHT INTENSIFICATION TRANSFORMS MULTIPLE ECOSYSTEM PROCESSES: EVIDENCE FROM A MESOCOSM EXPERIMENT

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Climate change is intensifying drought across the globe, with potentially profound but as yet uncertain impacts on the multiple functions and services provided by inland waters. In rivers and streams, more intense droughts could cross key physical or biological thresholds, eroding ecosystem condition and performance. Here we show experimentally how multiple ecological and biogeochemical food web functions respond to a gradient of drought intensity in mesocosms. We found that drought intensification led to a progressive attrition of ecosystem processes as specific functions were eroded. Both linear and non-linear responses to increasing drought stress were observed, with threshold responses of functions common, associated with three critical drought transitions: habitat contraction, fragmentation and drying. Several functions (e.g. gross primary production) were surprisingly sensitive to low-intensity drought, declining strongly in response to reduced water level. More intense droughts altered the metabolic balance of aquatic ecosystems, accelerating methane production, and degraded aquatic food web processes, from those driven by basal producers to top predators. Our research suggests relatively small changes in habitat can yield large changes in functioning. Consequently, future drought intensification can be expected to have far-reaching consequences for aquatic ecosystem service provision without management strategies to protect freshwater habitats.

REPEATED DROUGHT DISTURBANCES CAUSE AQUATIC COMMUNITIES TO DIVERGE TAXONOMICALLY AND FUNCTIONALLY: A STREAM MESOCOSM EXPERIMENT

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Understanding and predicting consequences of drought intensification is vital for effective preservation, or restoration, of biodiversity and related ecosystem services. Yet our ability to make such predictions and inform effective solutions is limited by the focus on taxonomic diversity rather than the functional components of communities. We conducted a two-year stream-mesocosm experiment, exposing aquatic invertebrate communities to repeated dewatering (drought treatment) or continuous flow (control), to determine if temporal patterns of freshwater biodiversity loss and/or gain in response to drought intensification are matched by similar patterns of loss and/or gain in functional diversity. The control community diverged taxonomically in composition with time due to losses and gains (turnover) rather than losses alone (nestedness), but the functional composition remained stable. Taxonomic divergence also occurred in the drought treatment, again due to turnover not nestedness, but was by contrast accompanied by functional divergence. This suggests repeated drought disturbances progressively alter both the functional and taxonomic characteristics of communities, whereas under non-drought conditions, functional composition is maintained through time despite taxonomic divergence. Our findings also suggest that while drought intensification increases temporal variation both taxonomically and functionally, the relative contributions of taxonomic and functional diversity components to temporal variation may remain unaltered by drought. Taxonomic temporal turnover was higher than functional temporal turnover, and functional temporal nestedness higher than taxonomic temporal nestedness, in both the drought treatment and control. Functional divergence in drying ecosystems may have unforeseen consequences for freshwater food webs and ecosystem stability with flow-on impacts on the services they provide.

THE EFFECT OF FINE SEDIMENT SIZE AND LOADING ON THE VERTICAL MOVEMENT OF A FRESHWATER AMPHIPOD

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Sedimentation and clogging of interstitial pore space is widely considered to be one of the most significant threats to lotic ecosystem integrity and functioning. This paper presents the results of a study examining the effect of fine sediment loading (benthic and hyporheic) and particle size on the vertical movement and distribution of the freshwater amphipod, Gammarus pulex, within running water mesocosms. The influence of body size on the ability of individuals to access subsurface sediments was also examined. Results indicate that when vertical hydraulic exchange is upwelling, increasing the volume of fine sediment deposition limited the ability of individuals to migrate vertically into subsurface substrates. Particle size and heterogeneity of deposited sediment had a significant effect on the vertical movement of individuals, with heterogeneous sand (4 – 0.25 mm) acting as the strongest filter of individuals followed by coarse (4 – 1mm) and fine sand (1 – 0.25 mm). The volume of deposited sediment and particle size also acted as a filter on the body size of organisms able to migrate vertically, with only smaller bodied individuals able to access the deeper layers of the column under the greatest sediment loading treatments. The wider implications of the findings for lotic ecosystems are considered in relation to reduced habitat availability and ecosystem functioning.

A PAN-EUROPEAN RESEARCH INFRASTRUCTURE NETWORK OF AQUATIC MESOCOSM FACILITIES - FROM MESOAQUA TO AQUACOSM

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Mesocosm experiments are a powerful tool to disentangle and quantify impacts of multiple stressors on whole ecosystems, and thus to gain mechanistic insights into complex ecological processes. As stressor effects are expected to vary widely among ecosystems and seasons etc., they should ideally be investigated over broad spatial and temporal scales. However, few mesocosm experiments were designed to make direct comparisons among multiple sites or over extended periods. Furthermore, separate research communities have developed mesocosm approaches in freshwater and marine environments; therefore, and because of many shared characteristics, improved exchange of expertise across the freshwater-saltwater divide is expected to spur technological and theoretical advances in all aquatic ecosystems. To seize this opportunity, a collaborative international Research Infrastructure Network project for coordinated aquatic mesocosm research (AQUACOSM) is established with support from the European Commission. AQUACOSM builds on MESOAQUA (2009-2012), a previously EU-funded network that involved 7 marine pelagic mesocosm facilities and 167 users that conducted 74 experiments. AQUACOSM (2017-2020) will greatly enhance that network by granting >340 users in total >11500 days access to its >20 facilities established in rivers and lakes, brackish and marine waters and both benthic and pelagic environments. AQUACOSM further aims to integrate academic research and industrial developments to advance mesocosm technology, instrumentation and data processing. Coordinated mesocosm experiments will be conducted along transects from the Mediterranean to the Arctic and across salinity boundaries. AQUACOSM offers numerous opportunities for external participants to join workshops, symposia and initiate or contribute to experiments at the AQUACOSM facilities.

MULTIPLE STRESSORS & STREAM MACROINVERTEBRATE DYNAMICS: A MESOCOSM EXPERIMENT MANIPULATING FINE SEDIMENT GRAIN SIZE & FLOW

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Land-use change to agriculture remains the dominant driver of biological change in both terrestrial and freshwater ecosystems. Agricultural stressors seldom operate in isolation, and their impacts on stream ecosystems generally reflect an integrated response to multiple stressors. Agricultural practices that increase catchment erosion can often result in fine sediment deposition in streams with adverse effects on benthic invertebrate communities. Changes in land and/or water use (e.g. water abstraction for irrigation) can also modify stream flow, that may interact with fine sediment deposition rates, thus modifying stressor effects. In this this study, we investigated the relationship between fine sediment grain size and flow velocity on macroinvertebrate community dynamics (i.e. benthic, drift and emergence densities) in 60 flow-through stream mesocosms. Our experimental treatments comprised four fine sediment treatments (no added sediment, silt: 0-0.125mm, fine sand: 0.125-0.250m, coarse sand: 1-2mm) combined with three flow velocities (fast, medium, slow) in a replicated full-factorial design. Invertebrate community- and population-level variables responded significantly to sediment and/or flow manipulation yielding both additive and non-additive outcomes, frewquently mediated through dynamical shifts among benthic, drift and emergence assemblages. Our results imply that fine sediment (of varying size) and reduced flow velocity can have pervasive detrimental impacts on stream invertebrates, especially for sensitive invertebrate taxa (e.g. EPT taxa).

HOW DOES CONNECTIVITY INFLUENCE THE EFFECTS OF DROUGHT DISTURBANCE ON STREAM ECOSYSTEMS?

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Droughts are predicted to increase in frequency and intensity due to climate change and increased water demand. There is thus an urgent need to improve our understanding of the ecological responses to drought and how they may change depending on connectivity at local and regional scales. For example, higher connectivity may promote post-drought recolonization by stream organisms and hence faster ecological resilience. We tested how drought, resource distribution and regional connectivity affect community responses in a mesocosm experiment where we manipulated flow (drought vs no drought), spatial arrangement of resources (aggregated vs. evenly spaced leaf bags) and regional connectivity (increased vs ambient recolonization by invertebrates) in 24 artificial flumes (each 6 x 0.20 m). We measured primary production (algal biomass accrual) leaf decomposition rate, fungal communities and benthic invertebrate at the end of a manipulated drought (7 days) and after a 3-week recovery period. Drought reduced invertebrate abundances, algal biomass and processing rates even after the recovery period. Aggregation of resources had a positive effect on microbial decomposition, fungal biomass and abundances of benthic invertebrates. A significant interaction between flow and resource arrangement on fungal diversity suggests that the effect of patch-scale connectivity affects microbial communities differently at different flows. Enhanced recolonization fastened the recovery of invertebrate communities exposed to drought and had a positive effect on algal biomass but a negative effect on fungal biomass, due most probably to changes in invertebrate community composition that modified food web interactions.

IMPACTS OF BROWNING ON PHYTOPLANKTON COMMUNITIES EXPOSED TO NUTRIENT ENRICHMENT

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Nutrient loading and browning by humic substances are two important and co-occurring stressors affecting lakes in Northern Europe. The combined impact of browning and nutrient enrichment on phytoplankton was assessed in a large-scale enclosure experiment, conducted in Lake Stechlin, north-eastern Germany, during summer 2015. The phytoplankton in the enclosures was initially dominated by a filamentous cyanobacterium, Dolichospermum zinserlingii (biomass 1±0.4 mg l-1), which collapsed after two weeks. Microcystin also occurred in all enclosures during the first two weeks of the experiment. Preliminary results indicate that browning reduced the total phytoplankton biovolume and -diversity, apparently as a result of light limitation. Although cyanobacteria generally tolerate low light intensities, the browning reduced their proportion, particularly that of Planktothrix. The strong absorption of blue light by the added humic substances is likely the most important mechanism accounting for this decline, because cyanobacteria require blue light to maintain their competitive advantage when growing at low light intensities. Also the chlorophytes decreased their proportion in the brown vs clear enclosures, whereas cryptophytes increased possibly because of their mixotrophic life-style. These changes indicate a shift from an autotrophic to a heterotrophic food web. Nutrient effects were less clear, probably because of top-down control by significant zooplankton populations developing in the absence of fish predation. In the brown enclosures, the unclear nutrient effects can also be related to less nutrient limitation, due to mixotrophs grazing on bacteria. However, the role of nutrients and zooplankton in explaining the observed shift from cyanobacteria to cryptophytes will require further exploration.

TESTING THE EFFECTS OF EXPERIMENTAL LAKE BROWNING AND NUTRIENT ENRICHMENT ON PRIMARY PRODUCTION IN LARGE-SCALE ENCLOSURES

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Increasing levels of humic substances and nutrients resulting from climate and land-use change are widespread. Both stressors threaten fresh waters individually and may also act in concert, but the interactive effects are not well known. To unravel how the biomass (chlorophyll a) and primary production (PP, 14C method) of three major size classes of phytoplankton respond to these stressors, we performed a seven-week experiment with natural lake plankton in a large enclosure facility (www.lake-lab.de). A nutrient gradient, corresponding to seven phosphorus levels ranging from oligo-mesotrophic to eutrophic conditions, was crossed with three levels of humic substances. In enclosures without humic substances added, rates of PP increased at increased nutrient levels, whereas chlorophyll a did not clearly respond to nutrients. In enclosures receiving humic substances, phytoplankton biomass and PP went through distinct phases during the experiment, mostly driven by light availability. PP sharply declined immediately after humic substances were added, whereas phytoplankton biomass declined later. The euphotic was greatly reduced directly after the addition of humic substances and only rose again after one month of bleaching. This gradually improved light availability in the enclosures. Picoplankton biomass started to increase concomitantly, presumably because the larger size fractions were heavily grazed by zooplankton. Overall, our results demonstrate that lake browning is a dominant stressor of planktonic primary producers, switching nutrient to light limitation even in oligo-mesotrophic conditions.

ALKALINE PHOSPHATASE ACTIVITY IN LAKE PLANKTON UNDER GLOBAL CHANGE - A LARGE-SCALE ENCLOSURE EXPERIMENT.

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Alkaline phosphatase activity in lake plankton under global change – a large-scale enclosure experiment on browning and nutrient enrichment effects.
Climate and land-use changes have increased the leaching of humic substances and nutrients from catchments into fresh waters, thus causing browning by coloured dissolved organic matter and eutrophication. We investigated the effects of these two stressors on the activity of the exoenzyme alkaline phosphatase (AP). The aim was to inform about nutrient conditions in lake plankton in the future, given that AP produced by algae and heterotrophic microbes provides bioavailable (inorganic) phosphorus for growth. We conducted an experiment in 21 large enclosures deployed in a deep clear-water lake in north-eastern Germany (http://www.lake-lab.de) by crossing three levels of browning (clear, meso-, polyhumic) with seven levels of nutrient supply corresponding to a gradient from oligo- to eutrophic conditions. We determined AP Michaelis-Menten kinetics at least weekly over the following 40 days by incubating plankton samples with a fluorogenic model substrate. Both stressors independently reduced AP activity and also affected AP kinetics interactively. Specifically, the observed reduction of AP activity with increasing nutrient supply was weakened at higher browning levels. Furthermore, the AP kinetics indicate that browning led to non-competitive inhibition, whereas elevated nutrient supply caused competitive inhibition of the enzyme. These results imply a reduction in the inorganic phosphorus provision from organic matter by both stressors, but different mechanisms mediating the effects. Overall, our results suggest that browning and nutrient enrichment can notably influence AP kinetics and thus affect phosphorus cycling in lake plankton under future global change.

MESOCOSM EXPERIMENTS REVEAL VERTICAL MOVEMENT AND SURVIVAL OF MACROINVERTEBRATES IN THE SUBSURFACE IN RESPONSE TO DRYING

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Streambed sediments may be an important refuge for benthic macroinvertebrates during hydrological disturbances including streambed drying. Sediment characteristics including particle size and interstitial pore space volume influence vertical connectivity, affecting their potential to act as a macroinvertebrate refuge during drying events. We used transparent artificial mesocosms containing different sediment sizes and interstitial pore volumes to directly observe the subsurface movements of five lotic taxa in response to water level reduction: Nemoura cambrica (Plecoptera: Nemouridae); Gammarus pulex (Amphipoda: Gammaridae); Asellus aquaticus (Isopoda: Asellidae); Hydropsyche siltalai (Trichoptera: Hydropsychidae) and Heptagenia sulphurea (Ephemeroptera: Heptageniidae) . We also examined the effect of drying duration (7, 14 and 21 days) on G. pulex survival in a temporary stream using mesocosms. Vertical movements made by individuals were significantly affected by decreasing interstitial pore space volume. The vertical movement of some taxa (e.g., N. cambrica) was largely unaffected by sediment treatment, whereas other taxa with a weaker affinity for the subsurface either became stranded in all sediments (H. sulphurea) or sediments with reduced pore volumes (e.g., H. siltalai). In field mesocosms, G. pulex survival in subsurface sediments was significantly reduced by surface water loss and significantly decreased with increasing duration of drying. Our results highlight the need to quantify species-specific responses to surface water loss and the duration of drying events to understand wider community and functional responses. Our results also highlight the usefulness of mesocosm experiments.

WARMING AND OLIGOTROPHICATION CAUSE SHIFTS IN FRESHWATER PHYTOPLANKTON COMMUNITIES

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Anthropogenic pressures such as climate change and eutrophication can result in rapid responses in freshwater ecosystems. Therefore, they have become model systems to investigate singular and synergistic effects of warming and fertilization in situ as well as in experiments. However, following widespread management efforts, we now see a Europe wide trend of nutrient decrease (re-oligotrophication) in many freshwater systems. We need predictions on community and functional responses to these new trends, especially in the context of temperature increase. To this end, we used a new experimental indoor mesocosms setup, the Planktotrons, to investigate the interactive effects of nutrient reduction and gradual temperature increase on a natural phytoplankton community. The results show a significant reduction of species richness through increasing temperature stress. Under constant nutrient conditions biomass was higher compared to the treatment with sequential nutrient decrease. An interactive effect of temperature stress and nutrient reduction on phytoplankton diversity could be observed, which lead to a hump shaped pattern over time in evenness and biomass production. Given the dependence of ecosystem functions on species diversity, we point out the necessity of careful monitoring of such patterns and appropriately adapted management plans. Multiple stressors could lead to unexpected (sudden) regime shifts, with far-ranging consequences for ecosystem services.

HIGH-RESOLUTION APPROACHES TO STUDY IN SITU MESOZOOPLANKTON ABUNDANCE AND MIGRATION IN LARGE LAKE MESOCOSMS

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Reliably quantifying zooplankton at high spatial and temporal resolution is a major challenge. Here we report on a combination of optical and acoustic approaches to assess in situ mesozooplankton abundance and migration in large lake mesocosms (http://www.lake-lab.de). The large dimension of the mesocosms (9 m wide, 20 m deep) and high-frequency sampling schemes (hourly vertical profiles by automated probes) have set a new level of demand on accompanying measurements of zooplankton. To meet this demand, we combined optical and acoustic approaches to produce data at much higher spatial and temporal resolution than can be achieved with classical net tows. In situ video images were acquired by a Mini Deep-Focus Plankton Imager (MDPI by Bellmare LLC, SanDiego, CA, USA) equipped with a far red light source. Acoustical backscatter data were obtained using Acoustic Doppler Current Profilers (ADCP; Nortek Signature1000). The ADCPs are able to resolve individual objects down to 500 µm size, whereas the MDPI allows identifying zooplankton (cladocerans, copepods, etc.) down to ca. 300 µm body length. To validate the in situ video and ADCP techniques, we compared results with those from net-tow samples fixed in formalin and analysed by semi-automatic image analysis that allows identifying crustacean zooplankton at the species or genus level for specimens 300 µm in body length or larger. Our first analyses suggest that the combination of in situ sonar and video techniques hold enormous potential to expand the spatial and temporal resolution of classical zooplankton assessments in mesocosms, and in other pelagic environments.

IMPACT OF DROUGHT AND POST-DROUGHT RECOVERY ON LEAF LITTER DECOMPOSITION IN STREAM MESOCOSMS

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Climate change and human activities are likely to increase the frequency and magnitude of extreme climate events such as droughts, with potentially profound consequences for freshwater ecosystems. Although many previous studies demonstrate how low steam flows reduce water quality and impair the structure and functioning of riverine ecosystems, we still lack an understanding of the factors that influence the extent and rate of recovery of the system from these events as water flow return to the long-term average. Here we report the results of an experiment conducted in stream mesocosms to explore the impacts of drought and the rates of ecological recovery of running water ecosystems typical of lowland chalk streams. We measured the response of a suite of ecosystem processes (i.e. leaf litter decomposition, gross primary production, ecosystem metabolism) during the drought and recovery phases, each of which ran for 12 months. We found that the drought altered the physical characteristics of the entire system, and that these effected persisted through the recovery year. Flow restoration had markedly contrasting effects among the various descriptors of community structure and ecosystem function. For instance, the extent of recovery of macrophyte production was limited, whereas the rate of leaf litter decomposition rapidly converged with undisturbed controls. Taken together, our data suggest the functional impacts of stream drying can be prolonged, and extend far beyond the drought period itself.

OPTIMISING MOWING STRATEGIES IN SHALLOW LAKES: CAN BOTH WFD AND RECREATION BE PLEASED?

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Shallow lakes can show alternative stable states with a clear water state stabilized by submerged plants, and a turbid state dominated by phytoplankton. External nutrient input is a dominant stressor for the clear water state, ultimately enforcing a shift to turbid conditions. The WFD calls for a good environmental status of surface waters. Therefore, many measures have been taken to reduce eutrophication and restore the clear water state and its submerged vegetation.

Growth of dense stands of submerged vegetation can cause nuisance for recreational activities such as boating or swimming. Consequently, nuisance control of dense vegetation is applied in many restored lakes. Due to the important stabilizing role of macrophytes in the clear water phase, combining the requirements of both WFD and recreation by mowing is a challenge.

The integrated ecosystem model PCLake is used to demonstrate the possibilities for optimising mowing strategies. This is done by evaluating the effects of mowing in the model using different timings and intensities of mowing in combination with the effects of external nutrient loadings.

PCLake indicates that the risk of shifting to a turbid state is increased by mowing. A temporal reduction of nuisance is only possible if nutrient loads are sufficiently low. On the other hand, careful mowing can also have beneficial effects: repeated removal of nutrients can slightly increase the critical nutrient loading, and hence decrease the chances of shifting to a turbid state. The model predictions are discussed in relation to empirical observations from Lake Oldambt in the Netherlands.

RECOVERY OF LAKE PUSIANO THROUGH THE REDUCTION OF EXTERNAL PHOSPHORUS LOADS. A 30 YEARS LONG RESEARCH SURVEY

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Lake Pusiano is a mid-sized subalpine Italian lake affected by long term eutrophication problems, that reached their maximum extent in mid-1980s. Using historical data and modelling approaches we reconstructed both the external phosphorus load (EPL) between 1960 and 2015 and the internal phosphorus load (IPL) between 1972 and 2015. EPL reached its maximum in the1980s with P values of about 21 t yr−1 while currently it is close to 6 t yr−1. IPL was one order of magnitude less and ranged between 0.25 t yr−1 (2015) and 3.6 (1985) t yr−1. The strong reduction of the P load determined a marked decrease of both P (from 200 to 23 µg L−1) and chlorophyll a (from 18 to 8 µg L−1) concentrations in the lake. The process of eutrophication and subsequent recovery, however, showed hysteresis between P load and in-lake P concentrations. In recent years, in particular, P concentrations (at winter overturn) seem to be independent from the P load. This has been related to modifications in the hydrological management of the lake, that favored P flush-out in fall, when the EPL is maximal. This process led to a marked decrease of the total P concentrations at winter overturn (23 µg L−1), which recently resulted lower than target concentrations (30 µg L−1) established by the Lombardy Region. The lake, nevertheless, suffers from the presence of the toxic cyanobacterium Planktothrix rubescens. Eradicating this species to further improve the lake water quality will likely require a supplementary abatement of the EPL.

RECYCLING NUTRIENTS IN FISHPOND SEDIMENT - A KEY STUDY OF FISHPOND HORUSICKÝ, CZ.

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More than 50% of arable land in the Czech Republic is under the risk of soil erosion. This results in high loss of soil particles rich in nutrients and decrease of soil organic matter as well as reduction of soil fertility. Czech landscape is rich in fishponds and fishpond systems. Fishponds have naturally a high potential of nutrient retention. The key role play fishpond sediments. An interesting opportunity could be the application of fishpond sediment, mostly containing high amount of nutrients and organic matter, back on fields. The main task of this paper is to introduce a trial study of possible technological process of nutrient recycling from the fishpond sediment using suction dredger and geotextile bags. This method approved to be very effective – compounds exploitable in agriculture production were retained efficiently. Water from the geotextile bags that entered back the pond represented only one potential risk – high concentrations of N-NH4 (20-30 mg l 1), but the effluent was sufficiently diluted by the fishpond waters. After 31 days was the sediment applied on the experimental field – 6 cm thick layer contained by an order of magnitude more nutrients (N, P, K) than is usually applied. We assume slowly proceeding transformation of nutrients in compounds available to vegetation during vegetation season. The project is aimed on soil fertility characteristics and crop in next two years.

PREVENTATIVE MEASURES TO CONTROL PHOSPHORUS IN A MESOTROPHIC LAKE

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The excavated lake “Waidsee” (area 0.24 km2; mean depth 13.5 m; max depth 28 m) is situated in the upper Rhine valley, Germany. It is of high recreational value and intensively used for swimming, fishing, diving and sailing.
In recent decades, nutrient and phytoplankton concentrations have increased, threatening the ecological structure and functions, and thereby the ecosystem services of the lake.
Five in situ P-precipitation systems were installed in 2002 to control most of the annual phosphorus (P) inputs. These systems, which operate 9 months / year, use iron hydroxide granules to bind P in lake water from 21 m depth.
As the lake has a small surface area in relation to its depth, deep water is only circulated irregularly. The P concentrations in the deep water have increased gradually in recent years, mainly due to internal P-loading. Between 2002 and 2007, the deep water contained approximately 310 kg P on average; however in 2015 this figure had increased to around 580 kg P. To target this deep water P-reservoir and the releasable P in the nutrient rich sediments, 94 t of lanthanum modified bentonite (LMB) were applied to the lake in February 2016.
This presentation will present data from pre- and post-treatment monitoring of the lake and outline the preventative strategies which have been implemented to maintain P concentrations within a mesotrophic state, thereby ensuring ecosystem functioning and the unrestricted recreational use of the lake.

EFFECTIVENESS AND LONGEVITY OF AL TREATMENT FOR LAKE RESTORATION

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Aluminum (Al) addition has been used for almost five decades to reduce the release of legacy phosphorus (P) in sediments and improve water quality in lakes, reservoirs, and seas. However, results have varied greatly, leading to contention and uncertainty as to the usefulness of this restoration method. Here, we analyzed data for 114 Al treated lakes from around the world to identify factors related to longevity of post-treatment water quality improvements. After treatment, nearly all lakes had initial improvements in water quality, but longevity of improvement varied greatly among lakes. Based on declines in epilimnetic TP, longevity averaged 11 years for all lakes (0 to 45 years). When modeled longevity estimates were used for lakes with improved conditions through the end of available monitoring data, average longevity increased to 15 years and total longevity reached >100 years for some lakes. The model we developed to identify factors driving longevity of water quality improvement showed that Al dose, watershed to lake area ratio, and lake morphometry were the most important explanatory variables (r2 = 0.82). The importance of other factors potentially related to longevity of Al treatment (e.g. aluminum to sediment mobile P ratios and the presence of benthic feeding fish) and relative cost effectiveness of this treatment method will also be discussed.

MACROPHYTE DIVERSITY ENHANCES NITROGEN (N) CYCLING IN AQUATIC SYSTEM

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Nitrogen (N) is one of the key nutrients causing eutrophication in freshwater ecosystems. Even though N is largely taken up by vegetation, little is known about the combined effect of different growth forms of aquatic vegetation for N cycling. The aim of our study was to evaluate the effect of richness of macrophyte species and growth forms (i.e. emergent, submerged and bryophyte) on N removal from surface water and N accumulation by plant photosynthetic biomass. We conducted a 100-day greenhouse experiment with twelve macrophyte species growing in monocultures as well as in mixed cultures in a factorial ANOVA design. We measured the N removal from surface water at three sampling occasions viz., July, August and September and N accumulation at the end of the experiment. Our study showed that higher N removal rates were associated with increasing species and growth form richness. While macrophyte growth form richness enhanced nutrient removal during the entire growing season, there were temporal differences in the importance of certain growth form combinations for N removal. Our analyses showed that combinations of emergent-bryophyte species positively affected N removal as well as N accumulation by plant photosynthetic biomass. In contrast, the presence of submerged species in mixed cultures tended to reduce the N accumulation in plant biomass. Both macrophyte species richness and growth form richness appear to be important for N cycling in aquatic systems. Moreover, our study highlights the importance of bryophytes that might represent the only or dominating growth form in subarctic and arctic wetlands.

Keywords: Aquatic plant ecology, bryophyte, complementarity, diversity partitioning, eutrophication, growth form, monoculture, mixed culture, nitrogen cycling, surface water

ASSESSING THE USE OF EARLY WARNING INDICATORS TO PREDICT REGIME SHIFTS IN TIME TO IMPLEMENT PREVENTATIVE MANAGEMENT

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Predicting sudden shifts in ecological structure and function at the ecosystem scale, known as regime shifts, is an important goal of lake management. Shallow lakes have been used as an important test-bed with which the responses of simple ecological indicators to pressure changes (e.g. nutrient pollution abatement; fish stock manipulation) can be assessed. Evidence from shallow lakes suggests that non-linear transitions between stable states (e.g. between algae and macrophyte dominated states) can be manipulated and theory indicates that these transitions are preceded by an increase in variance and/or auto-correlation. Statistical early warning indicators (EWIs) capable of predicting transitions have been developed, mainly using simulated or experimental data. Recent tests using long-term monitoring data from lakes have indicated low levels of agreement between early warning indicators and statistically defined tipping points. We address this issue using long-term data from CEH's lake monitoring programme to report on an assessment of ecological stability in lakes using ecological indicators across multiple trophic levels. We apply EWIs to assess their use in predicting tipping points in these data and contrast this with a known, and naturally occurring, regime shift driven by a sudden decrease in internal phosphorus loading in Loch Leven, UK, with a view to their applicability for use in preventative management.

EVALUATING THE RE-ESTABLISHED LAKE KARLA (GREECE): CONTRIBUTION TO ITS RESTORATION

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During the last decades, the natural environment of Greek lakes has come against the increasing demands for sufficient use of freshwater, as well as the conflicting uses, pressures and threats for its existence. Lake Karla was one of the most important wetlands of Greece with many benefits not only to biodiversity preservation, to water balance of the watershed, but also to local economy in terms of fisheries. Its drainage, in 1962, created a lot of environmental problems and led to the local economy contraction. This newly re-established water body is considered a vital aquatic ecosystem as it is listed in the network of Natura 2000. The monitoring results, the pressures and their causes that affected the restoration effort are presented. The assessment of the water quality is achieved by evaluating the results of the monitoring and fieldwork programs that Management Body of Ecodevelopment Area of lake Karla performs the last four years funded by European Union. The results indicate strong eutrophication along with threats to biodiversity. The delay of implementation of Lake Karla reconstruction project, the decline from the proposed Environmental Terms and the lack of environmental policy are the most important cause of its degradation. The present paper aims to improve the effectiveness of regional development policies related to water management and restoration of lake Karla acting also as a paradigm for similar Mediterranean shallow lakes.

AUTOCHTHONOUS CALCITE PRECIPITATION IN THERMALLY STRATIFYING HARD-WATER LAKES AND ITS RELATION TO THE STRUCTURE OF THE PELAGIC COMMUNITY.

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Pelagic calcite (CaCO3) precipitation is a common phenomenon in hard water lakes. Starting in late spring or early summer, the crystals appear in the water column. During the course of a year several metric tons per square kilometer lake surface can be produced. Being small, numerous and intensely light-diffractive, the crystals induce a number of ecological effects. The master variable to regulate the process is pH, which in turn is impacted by the intensity of CO2 uptake by photosynthesis and CO2 release due to respiration. Theoretically, starting at pH ≥8.2 the lime-carbonic-acid equilibrium (LCAE) is readily pushed over to the carbonate side. Since calcium carbonate is almost insoluble in water, calcite crystals should start to precipitate. However, empirical data from hard water lakes in NE Germany indicate that at saturation indices <4 calcite concentrations never exceed 0.4 mg/L. Beyond this threshold concentrations may range between <0.001-4.0 mg; which indicates that the process is not merely subject to stoichiometry. Data on phytoplankton collected from these lakes indicate that because of specific physiological properties cyanobacteria might have a special potential to trigger calcite precipitation. Moreover, it appears that the structure of the planktonic community (autotrophic vs. heterotrophic) has a decisive impact on the position of the LCAE and is therefore critical to the timing and intensity of calcite precipitation. In our paper we will present data on the intensity of calcite precipitation in hard water lakes of different trophic status and relate those findings to the structure of the planktonic community.

MITIGATING CYANOBACTERIAL BLOOMS: SYSTEM DIAGNOSTICS AND IN-LAKE MEASURES

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Global expansion of cyanobacterial blooms urges for counter measures to improve water quality and to minimize impairment of important ecosystems services. Broad-scale generalizations will not deliver sufficient support for adequate treatment of the growing problem. To control or mitigate cyanobacterial blooms it is crucial to have insight in the underlying causes and features of the water body as each lake is unique. A classification of types of causes, which is very useful in problem solving, will be presented. A proper diagnosis will deliver the needed insight and will guide to the most promising set of measures. Here, in-lake measures are particularly important in speeding-up recovery and in bringing real-time relief. In lakes where external nutrient load or external and internal load are main drivers of cyanobacterial nuisance, catchment measures usually take too long to bring, if at all, any relief. In lakes where internal load is fuelling cyanobacterial blooms or in oligotrophic lakes where neither external nor internal nutrient load, but accumulation is causing the problems, in-lake measures are the sole type of logic interventions. Particularly powerful are geo-engineering techniques that can rapidly remove cyanobacteria out of the water column and/or permanently immobilise phosphate. Examples will be provided of whole lake diagnoses and experiments. Such effective suppression of cyanobacterial blooms is needed today in many waters that otherwise also in the upcoming decades will not improve due to ongoing massive point source and nonpoint source pollution, especially in developing countries and countries in transition, but also in areas with continuing diffuse loading.

EFFICACY OF COAGULANTS AND BALLAST COMPOUNDS IN MITIGATE EUTROPHICATION FROM WATER OF THE TROPICAL BRACKISH LAGOON JACAREPAGUÁ (RIO DE JANEIRO, BRAZIL)

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Eutrophication is considered the most important water quality problem in freshwaters and coastal waters worldwide. Removal of cyanobacteria from the water column and immobilizing phosphorus in the sediment using a combination of coagulant and P-adsorbing ballast is a promising technique to mitigate eutrophication. In laboratory experiments, we tested the efficiency of two coagulants, polyaluminium chloride (PAC) and chitosan (made of shrimp shells), alone and combined with a red soil (RS), to remove natural populations of cyanobacteria, from water collected at an urban brackish coastal lagoon. Further we tested the efficiency of coagulants combined with RS and Phoslock to bind P in the sediment. PAC was a very effective coagulant to settle down cyanobacteria when applied at low doses (≤ 8 mg Al L-1), while at high doses (≥ 16 mg Al L-1) large flocks aggregated in the top of test tubes. In contrast, chitosan was not able to form flocks, even in high doses (> 16 mg L-1) and did not settle down cyanobacteria when combined with ballast. The RS itself removed 33-47% of the cyanobacteria. This removal was strongly enhanced when combined with PAC in a dose dependent matter; 8 mg Al L-1 was considered the best dose to be applied. The highest reduction in sediment P-release was obtained with Phoslock + PAC (95%), while RS + PAC showed a lower reduction (63%). Combined coagulant and ballast application seems an efficient, cheap, fast and safe curative measure to mitigate eutrophication in periods when particularly needed.

BROAD-SCALE ANALYSIS OF THE EUTROPHICATION PROBLEM AT LESSER PRESPA LAKE (GREECE) AND PRELIMINARY CONSIDERATIONS FOR CURATIVE AND PREVENTIVE MEASURES‘

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The Lake Lesser Prespa in Greece is internationally acknowledged as a vital habitat for migratory waterbirds such as the Dalmatian and Great White Pelicans which breed there in large populations. Despite being a protected area,the lake shows clear signs of eutrophication and has a history of cyanobacterial blooms (Microcystis sp.).The findings of a regular water monitoring during 2013-2015 indicate that nitrate enriched water is draining from the agricultural fields while soil phosphorus concentrations have built up to levels that exceed crop needs. Besides,the annual bird-induced nutrients via their excrements may contribute significantly to the eutrophication enhancement.The subsequent formation of organic and nutrient-rich sediments locally in the lake specifies the risk of nutrient diffusion towards the lake water.The identified nutrient inputs to the lake should be therefore controlled in order to prevent the prolonged eutrophic state of the lake and mitigate the cyanobacteria nuisance.A phosphorus-adsorption experiment suggests the promising role of the local iron-rich soil which is available at the surroundings of Prespa area - although it showed lower effectiveness compared to widely used modified clays (Phoslock,modified zeolite).The use of such material is expected to favor the reduction of water column phosphorus via the formation of Fe-P complexes. However further research is needed on the optimal dosage. Based on the outcomes of the essential system analysis of the lake,efficient,easy,safe and cheap curative measures could be used in order to achieve the recovery of the lake ecosystem.

CHITOSAN AS COAGULANT TO REMOVE CYANOBACTERIA MAY CAUSE RAPID CELL LYSIS AND LEAKAGE OF CELL CONTENTS

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Combining a coagulant and a ballast to remove cyanobacteria from the water column is a promising technique to mitigate cyanobacterial nuisance and well used in lake restoration. The organic, biodegradable polymer chitosan has been promoted as a coagulant and is viewed as non-toxic. In this study we show that chitosan may rapidly kill certain cyanobacteria leading to release of cell contents in the water. A strain of Cylindrospermopsis raciborskii and one strain of Planktothrix agardhii were most sensitive. A 1.3 hour exposure to a low dose of 0.5 mg l-1 chitosan already almost complete killed these cultures resulting in release of cell contents. After 24 hours, reductions in PSII-efficiencies of all cyanobacteria tested were observed. EC50 values varied from around 0.5 mg l-1 chitosan for the two sensitive strains, via about 5 mg l-1 chitosan for an Aphanizomenon flos-aquae strain, a toxic P. agardhii strain and two Anabaena cylindrica strains, to more than 8 mg l-1 chitosan for a Microcystis aeruginosa strains and another A. flos-aquae strain. Differences in sensitivity to chitosan might be related to polymeric substances that surround cyanobacteria. Rapid lysis of toxic strains is likely and when chitosan flocking and sinking of cyanobacteria is considered in lake restoration, flocculation efficacy studies should be complemented with investigation on the effects of chitosan on the cyanobacteria assemblage being targeted.

AQUATIC PLANT UPDATE OF PHOSPHORUS AND REMOVAL BY MECHANICAL HARVESTING FOR PHOSPHORUS CONTROL IN LAKES

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One of the challenges of nutrient control and lake restoration is maintaining a stable state after implementation of lake restoration measures. Very little is known about the role of aquatic plants with respect to nutrient uptake and the mass of nutrients (in particular phosphorus) that are removed by aquatic plants relative to watershed inputs and nutrient stores in sediments. A study was conducted at Kohlman Lake, Minnesota, United States, to evaluate the potential nutrient control benefits that may be had with mechanical removal of aquatic plants in shallow lakes. The study lake is shallow (<4m maximum depth), has a large watershed to lake area ratio, and experiences high nutrient loads throughout the year. Several lake restoration measures have been applied: removal of invasive aquatic plants, alum treatment of lake sediments, and removal of common carp. The response has been a significant increase in aquatic plants as well as a notable reduction in phosphorus in the water column.

A two year study was conducted to evaluate the mass of phosphorus that resides in aquatic plants throughout two growing seasons and the mass of phosphorus that may be removed by mechanical harvesting. A relatively simple finite difference completely mixed model was developed to evaluate the overall phosphorus balance with these measures as well as the potential effect of harvesting on phytoplankton growth. The study concluded that mechanical harvesting can be a cost effective means to remove nutrients from a system and it has the potential to extent the life of an alum treatment by reducing the phosphorus deposition to lake sediments.

PHOSPHATE STRIPPING BY HYPOLIMNIC OXYGENATION OF LAKE OUDERKERK: A HIGHLY EFFECTIVE MEASURE TO CONTROL CYANOBACTERIAL BLOOMS

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Lake Ouderkerk is a large dimictic sand extraction pit near Amsterdam (the Netherlands) with a poor water quality. Due to high phosphate concentrations in the water layer, the lake suffered yearly from blooms of green algae and Cyanobacteria (blue-green algae). The sediment of the lake is P-rich and during stratification the hypolimnion becomes anoxic due to the high biological oxygen consumption. As a results large amounts of phosphate are mobilised from the sediment to the water layer. Since 2010 cold water from the hypolimnion is extracted for the sustainable cooling of buildings in the direct surrounding of the lake. After use the extracted P-rich water from the hypolimnion is returned into the epilimnion of the lake. To prevent a further deterioration of the water quality due to this additional circulation of phosphate, the hypolimnion is oxygenated to stimulate phosphate binding by the iron-rich sediment. The effects of hypolimnetic oxygenation on the water quality and the development of phytoplankton were studied during a 6 years monitoring program. The results reveal that oxygenation strongly decreases the release of phosphate into the hypolimnion which together with the epilimnic fixation of phosphate by pelagic micro-algae, has resulted in a strong decrease of the total-P concentrations in the lake water (by 85 %). As a consequence, growth of algae is strongly reduced and Secchi depth (water transparency) has strongly increased.

STOP FEEDING THE DUCKS: A WAY TO IMPROVE WATER QUALITY IN URBAN SYSTEMS?

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Preventing eutrophication in aquatic systems can take on many forms. In urban lakes and ponds artificial feeding (e.g. bread) of waterfowl may account for high loading of phosphorus and nitrogen to the water system. This feeding has a threefold effect on the water quality: (1) direct addition of organic material to the system, (2) excretion of nutrients by birds and (3) attraction of extra birds by increased food availability. Scientific underpinning of the effect on the whole lake ecosystem of these combined processes is currently lacking. Meanwhile, management on feeding is currently being carried out, but has potential for societal backlash due to the nature-education value of 'feeding the ducks'. Here, we quantified the effects of artificial feeding using a combination of experimental data, field observations and modeling exercises with an extended version of the ecosystem model PCLake. We determined rates of decomposition and nutrient release from commonly used food materials (whole meal bread, white bread). We also gathered data on feeding behavior and used this, combined with literature data, to determine plausible ranges of food input. Empirical relationships of waterfowl nutrient excretions were used to determine the added loading to the system from the bird population. By using these data to extend the PCLake model we were able to determine the effects of artificial feeding on the state of the ecosystem, i.e. turbid or the desired clear state. This allows us to test the feasibility of prohibiting artificial feeding as a preventative or restoration strategy for our urban waters.

CONTROLLING CYANOBACTERIAL BLOOMS IN AN URBAN LAKE USING QUAGGA MUSSELS (DREISSENA ROSTRIFORMIS BUGENSIS)

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Many city ponds and small lakes suffer from cyanobacterial blooms due to eutrophication. This hampers the fulfilment of societal services and poses health risks for citizens and pets. As eutrophication control is not always feasible due to practical and economic limitations, there is a need for alternative methods. The application of filter feeding bivalves is considered a promising curative method. In The Netherlands, the quagga mussel (Dreissena rostriformis bugensis) is a rapidly expanding species that feeds on phytoplankton. In 2013-2014, we constructed an artificial reef of 1600 crates (each crate 30x45x90 cm) that was overgrown with quagga mussels in a 1.1 hectare shallow, eutrophic urban lake that frequently suffered from cyanobacterial blooms. While no other interventions were made, water quality improved and cyanobacterial blooms have not been reported anymore since the completion of the reef (Spring 2014), indicating the efficacy of the mussels. Mean summer chlorophyll-a concentration decreased from 33 (SE ±7) µg L-1 (2008-2012) to 10 (±2) µg L-1 (2014-2016). Mean summer total phosphorus concentration decreased from 0.14 (±0.02) mg L-1 (2008-2012) to 0.07 (±0.01) mg L-1 (2014-2016), and turbidity decreased from 5.0 (±1.1) FTU (2010-2012) to 3.0 (±0.6) FTU (2012-2014). As the expected lifespan of a quagga mussel is about four years, propagation is of concern for the continuation of a living reef, as no sufficient reproduction has been observed to sustain a viable population for a longer term. The quagga mussel is considered an invasive exotic species and introductions should therefore be considered carefully.

ASSESSING WATER QUALITY AND MACROPHYTE RESPONSES TO PHOSLOCK APPLICATION

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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 communities following Phoslock applications including, for example, assessing changes in macrophyte functional groups, macrophyte/algal percentage cover and macrophyte diversity index scores. Concluding remarks will target the ecological processes that are holding back desirable macrophyte recovery and give an overview of preliminary findings from lab-based experiments. These experiments try and address general and species specific responses to Phoslock to try to explain the lack of macrophyte recovery in these treated lakes.

NUTRIENT LIMITATION IN FRESHWATER ECOSYSTEMS - EXPERIENCES FROM FIELD STUDIES

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Understanding the reasons and effects of nutrient limitation is crucial in the context of eutrophication of freshwater ecosystems. Although different conceptual or analytical methods have been used, most of the numerous studies that have been undertaken focused on different forms of nitrogen (N), phosphorus (P) and the simultaneous measurements of chlorophyll a (Chl-a) and phytoplankton.
Recently, the role of P and N has been the subject of controversial discussion amongst limnologists and other lake restoration scientists. Various theoretical paradigms relating to nutrient limitation have emerged as potential decision support systems for authorities and policy makers.
In our opinion, the differences in site-specific conditions (such as mixing behaviour, depth, catchment characteristics and nutrient loadings in sediments) of freshwater ecosystems play an important role and have to be explicitly taken into account when analysing processes of eutrophication and/or proposed restoration measures in the light of nutrient limitation.
This presentation will outline monitoring data from different fresh- and brackish water ecosystems. It focuses on situations where growth is either N or P limited, depending on the relevant paradigm. Experiences from fieldwork studies are presented and serve as the basis to discuss contrasting paradigms of nutrient limitation.

RESPONSE OF MODIFIED CLAYS IN THE CONTROL OF SEDIMENT INTERNAL P INFLUENCED BY SUSPENDED PARTICULATE MATTER (SPM) IN SHALLOW EUTROPHIC LAKES AND THE EFFECTS ON BENTHIC MACROINVERTEBRATE COMMUNITY.

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In this study, field mesocosom experiments were carried out to study the effects of a lanthanum-modified bentonite (LMB) and a thermally-modified calcium-rich attapulgite (TCAP) on sediment internal P control and their influence on benthic macroinvertebrate community strcutures. Furthermore, a laboratory incubation study was carried out to investigate the effects of suspended particulate mattter (SPM) on sediment P control of LMB and TCAP. Field results indicated that LMB and TCAP can initially effectively inhibit P release from sediment within five months when compared with control treatment. However, their efficiency diminished after seven months application. This can be resultant from the gradual enhanced labile P content in sediment as evidenced by the diffusive gradients in thin films (DGT) test results. P fractionation analysis indicated that over time, LMB and TCAP will lose their ability to reduce mobile phosphorus in sediment, but they can surely cause a significant increase of calcium bound and residual phosphorus fractions in sediment. Laboratory incubation confirmed that SPM addition can cause a sharp increase in P flux across sediment-water interface as well as an increase of mobile phosphorus in surface sediment. However, geoengineering materials have not been able to exert reduction in macroinvertebrate communities in treated sediment. This study indicates that an effective dose caculation should take SPM effects into consideration in shallow and turbid lake restoration using geoengineering in long-term management.

LEAF LITTER DECOMPOSITION ALONG THE LONGITUDINAL PROFILE OF A TEMPORARY MEDITERRANEAN STREAM: SPATIAL AND SEASONAL VARIABILITY

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Temporary rivers and streams are the dominant watercourses in Mediterranean regions and their spatial extent is expected to increase worldwide as a result of ongoing global change. However, these systems are a recent addition to freshwater ecology and their highly heterogeneous structure is far from that considered in classical paradigms. Consequently, there is an urgent need to better understand the ecology of these systems, and to this end, it is essential to consider their temporal and spatial heterogeneity due to flow variation. Our aim was to describe leaf litter decomposition along the longitudinal profile of a temporary Mediterranean stream with high variability in flow conditions (perennial lentic, perennial lotic and intermittent) in two contrasting seasons: winter and summer. We used coarse- and fine-mesh bags containing Populus nigra leaves to examine changes in decomposition rates, litter quality and decomposer communities. Our results indicated that large fluctuations in flow along the stream were accompanied by large fluctuations in leaf litter decomposition. In winter, dry and emerged conditions on intermittent reaches resulted in lower decomposition rates than in perennial reaches. In summer, an unexpected increase in precipitation events enhanced differences in flow along the stream. Local conditions modulated the inundation regime of intermittent reaches, resulting in higher decomposition rates in the more inundated one, similar to rates in permanently flowing reaches. To better understand the functioning of highly heterogeneous environments such as temporary streams, we should assume their structure as a changing mosaic of contrasting habitats and characterized their conditions properly.

SPATIOTEMPORAL VARIABILITY IN DISSOLVED ORGANIC MATTER QUALITY AND CO2 FLUXES DURING A SEVERE DROUGHT IN AN INTERMITTENT STREAM

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Intermittent streams are an important component of river networks in arid and semiarid regions, and their surface area is expected to increase in Mediterranean zones as a consequence of climate change. The natural drought periods gradually disrupt the hydrological longitudinal connectivity into isolated water pools, and enhance severe biogeochemical heterogeneities. The aim of the study was to explore the spatial and temporal variability in dissolved organic matter (DOM) quantity and quality, and carbon dioxide (CO2) fluxes, induced by a severe drought episode. An intensive sampling was performed in 15 sites in an intermittent Mediterranean stream (Fuirosos, NE Iberian Peninsula) during a summer drought episode. The hydrology was described by discharge measurements and pond isolation time. DOM optical properties were analyzed by absorbance-fluorescence spectroscopy and dissolved CO2 was measured in-situ with infrared analyser. The drought interrupted the flow for 90 days. During this period, isolated water pools showed a 15-fold increase in DOC and a 5-fold increase in dissolved CO2. The results of this study might improve the understanding of carbon cycling in the context of climate change in Mediterranean areas.

EXPLORING MACROINVERTEBRATE COMMUNITY STRUCTURE AT LOCAL SCALE: A CASE STUDY IN AN INTERMITTENT STREAM

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Macroinvertebrate communities exhibit high variability in taxa richness, abundance and structure at different spatial scales. Environmental factors, dispersal driven dynamics and biotic interactions are commonly considered the main drivers of this variability. Space has been generally used as a proxy to distinguish between biotic processes and environmental forcing in large to medium size systems but there is still a lack of knowledge about its importance at fine scales. To fill this gap we considered environmental as well as spatial variables with the aim to explain taxa richness, abundance and structure of macroinvertebrate communities at local scale by using geostatistical and multivariate spatial analysis. Sampling activity was performed in May 2015 using a specific in situ sampling design along a representative reach of an intermittent system (Baganza stream, Northern Italy). Our work highlighted a strong spatially structured environmental control of macroinvertebrate abundance directly related with depth, with the greater number of organisms near the shorelines. Taxa richness and community structure resulted less affected by spatial and environmental variables. Our main conclusion is that while organisms can occupy almost any position in the watercourse, their abundance is modulated by habitat preference and tolerance range. Our results improve the knowledge about the fine scale organization of macroinvertebrate communities in intermittent streams.

TEMPORAL VARIABILITY OF FISH POPULATIONS AND COMMUNITY ASSEMBLAGES FROM MEDITERRANEAN PERENNIAL AND INTERMITTENT STREAMS: MANAGEMENT IMPLICATIONS

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Mediterranean streams and rivers are characterized by a strong seasonality and interannual variability, where intermittent rivers (IRs) represent a high proportion of the stream network. Flow permanence is one of the most important determinants of fish population and assemblage structure, which may change drastically over different seasons (e.g. habitat contraction and deteriorating water quality across the summer). This complicates biological quality assessments and limits their usefulness for informing management and conservation efforts. In this context, the TRIVERS project aims at providing new tools to improve the management of IRs and the adequate implementation of Water Framework Directive. In our study, several IRs and perennial Mediterranean stream reaches were selected, including both natural and hydrologically impacted reaches, and sampled at three different periods to capture different flow conditions. Temporal changes in fish community composition, population structure and abundance were explored, and biological quality assessed. In non-impacted perennial rivers, biological quality was stable across seasons. In IRs, summer flow cessation resulted in increased fish abundance and lower biological quality, with stronger effects in hydrologically impacted rivers. Although isolated pools act as important refugia during summer, the rise of temperatures increases the risk of parasite infections. Moreover, resource competition in pools may favor generalist and tolerant species, resulting in a decreased biological quality. These effects may become more frequent in Mediterranean- climate regions, where severe stream flow deficits are predicted in the face of global change.

EFFECTS OF DURATION AND FREQUENCY OF NON-FLOW PERIODS ON STREAM BIOFILM METABOLISM

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Non-flow events are common in Mediterranean streams and have large effects in fluvial ecosystems. However, it is uncertain in which way the duration and frequency of non-flow periods affect the metabolism of these streams. We analyzed the effects of duration and frequency of non-flow events on the epilithic biofilm metabolism of 60 Mediterranean streams in NE Iberian Peninsula. The selected streams had different flow regimes (duration and frequency of non-flow events), in order to capture the influence on metabolism response. We measured metabolism (respiration and net metabolism) of epilithic biofilm under standard (laboratory) conditions of nutrients, light and temperature. We observed that gross primary production (GPP) and respiration (CR) were higher in permanent streams than in temporary streams. The GPP/CR ratio was generally higher than 1 in permanent streams and lower in the temporary ones. It means that epilithic biofilms from permanent streams were more autotrophic than those from temporary streams, showing major effect of non-flow periods on the autotrophic components of epilithic biofilms. We also observed that non-flow frequency affected GPP (negatively) and CR (positively) and that the metabolism was influenced by the short history of flow patterns, being the 7 days before sampling the hydrological parameter affecting the most the biofilm metabolism. Our conclusions might help to predict the effects of global climatic change predictions on stream and rivers ecosystems.

IS IT POSSIBLE TO SEE THE FOOTPRINT OF A ONCE OCCURRING DROUGHT IN THE MACROINVERTEBRATE COMMUNITY COMPOSITION OF A PERENNIAL STREAM AFTER A LONG TIME? A PILOT STUDY

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Attributable to climate change, it is expected that the frequency and severity of dry periods will increase in the near future. It is clear and well researched that a change from perennial to intermittent type is a remarkable shift in the life of a stream and consequently the stream dwelling invertebrates have to adapt to the new conditions. The community composition completely transform to a definitely different one. However, the long term effects of an accidentally, once occurring relatively short (one or two months) dry period on communities of a usually permanent stream which has no drought history must be highly different and our knowledge about is very limited. In this pilot study, our aim was to figure out if the effect of a drought in a previously perennial stream is detectable after a long time period. For this, we compared macroinvertebrate datasets of three perennial streams from the Mecsek Mountains, SW Hungary from 2009 and 2015. One of these streams experienced a two-month-long drought in the summer of 2012, while the other two maintained continuous flow. There were slight differences between each stream in the two time periods. Our study suggests, however it was only a pilot, that three years are more than enough for a small mountainous stream, which had no drought history, to regain its pre-drought status, even if it was a severe and not predictable event. The conference participation was supported by the Doctoral Student Association of University of Pécs.

GLOBAL PERSPECTIVE OF PARTICULATE ORGANIC MATTER DYNAMICS IN INTERMITTENT RIVERS AND EPHEMERAL STREAMS

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Half the channel length of the world's river network comprises intermittent rivers and ephemeral streams (IRES), which cease to flow at some time of the year. Moreover, IRES expand in space and time following climate change, water abstraction, and land use alteration. During dry phases, large quantities of particulate organic matter (POM; e.g. leaves, algal biofilms, herbs) accumulate in IRES. When flow resumes, large quantities of POM can be transported to downstream reaches, where they undergo further decomposition. This POM can be an important source of carbon (C) for heterotrophic consumers and its processing can cause anoxic events downstream of river networks jeopardizing biodiversity and altering freshwater resources quality. Are our understanding and estimates of carbon processing in river networks still accurate when IRES are included?
Supported by an international research network (http://1000_intermittent_rivers_project.irstea.fr/), we i. quantified POM accumulation along 209 dry streambeds from 22 countries, ii. explored the key environmental drivers and iii. assessed the ecological consequences of first flow pulses on downstream receiving waters. We measured the total C and nitrogen (N) content of POM samples and the DO consumption in respirometers containing POM in the presence or absence of a microbial inoculum. First results indicate that dry riverbeds accumulate important quantities of POM and that rewetting events are biogeochemical hot moments. The relationship between POM quality and biodegradability differ from those reported in aquatic and terrestrial environments. IRES could contribute substantially to the global C cycle and their inclusion into global models of C fluxes is urgent.

SCIENCE & MANAGEMENT OF INTERMITTENT RIVERS AND EPHEMERAL STREAMS: A EUROPEAN PERSPECTIVE

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A large proportion of the European river network comprises intermittent rivers and ephemeral streams (IRES) that recurrently and naturally stop flowing or dry. Due to global change, the number of artificial IRES is increasing. Intensified research over the past decade has highlighted the prevalence and value of these systems, which have been overlooked by freshwater scientists for too long. Reflecting increasing academic research, IRES are also receiving greater attention from water resource managers, notably within the context of the Water Framework Directive. The COST Action SMIRES (Science and Management of Intermittent Rivers and Ephemeral Streams, www.smires.eu) aims to synthesize fragmented knowledge in IRES hydrology, ecohydrology, biogeochemistry and ecology, and translate it into tangible tools for adequate biomonitoring, protection, conservation and restoration. Important SMIRES products are large-scale maps of IRES based on available hydrological data and a citizen-science network monitoring intermittence in Europe. Also, guidelines for the establishment of environmental flows in IRES will be produced, including a comprehensive assessment of the socio-environmental effects of flow regime alterations in IRES. And (dis)similarities between the biogeochemistry of IRES sediments and soils will be explored, as a first step towards the development of large-scale biogeochemical models for IRES. Current biomonitoring tools will be adapted and novel approaches developed based on recent advances in metacommunity, functional, terrestrial and molecular ecology. We present SMIRES objectives and preliminary results on our mission to improve our understanding of IRES and respond to the challenges of managing dynamic river ecosystems.

LATERAL AND LONGITUDINAL CHANGES IN SNAIL ASSEMBLAGES ALONG A SUBMEDITERRANEAN TEMPORARY RIVER

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Temporary rivers are distinctive ecosystems characterised by alternations in dry and wet phases. Spatial and temporal changes in flow dynamics affect environmental parameters and cause shifts in aquatic and terrestrial invertebrate assemblages. Thus, the aims of this study were to determine lateral and longitudinal changes in snail assemblages along the temporary Krčić River, Croatia. Terrestrial snails were sampled using pitfall traps at 36 sites along 10 km of the river, within two main habitats: riparian and karstic. In total 4,346 individuals belonging to 49 species were collected. Lateral changes in snail assemblages were more pronounced than the longitudinal, with significantly higher species richness, abundance and diversity in riparian than in the karstic habitats. Longitudinally, snail species richness increased from the upper towards the lower reaches of the river, but the differences were significant solely between karstic habitats of upper, middle and lower reaches and riparian habitats of lower reaches. Asymmetric response was observed in terms of snail abundance, which was the highest in the riparian habitats of upper reaches, decreasing in the middle reaches, but increasing again in the lower reaches. Overall, snail assemblages were strongly affected by environmental conditions in riparian habitats – vegetation, low soil temperature and high air humidity, showing that riparian habitats are more favourable for terrestrial snails than karstic habitats. The combined effect of climate change and water management could increase duration of dry phase, and based on our results those changes could negatively affect not only aquatic invertebrates, but also terrestrial snails.

IMPACTS OF DRYING ON THE ABUNDANCE OF GAMMARUS FOSSARUM POPULATIONS IN SMALL STREAMS IN CENTRAL EUROPE

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Climate change strongly affects the flow regime of small streams and causes, among other, more frequent and longer drying up. Changes in the population dynamic of aquatic invertebrates and the rate of their recovery after this disturbance indicate the duration of the dry-phase impact on populations of model organisms.

The main aim of our study was to compare the fluctuation in abundance of Gammarus fossarum populations in relation to dry-phase using spring and autumn samples from 9 pairs of near-pristine streams (intermittent/permanent in each region) sampled in 2012-2015 during BIODROUGHT project (www.biodrought.eu).

We assessed the impact of drought duration (measured in days), the accessibility of refugia and other factors on the abundance of the model species in intermittent streams within year (before and after drying) and between years. Moreover, we investigated the rate of recolonization. Former research proved that intermittent streams are recolonized after dry period initially by bigger males, probably by upstream or downstream migration from permanent reaches. According to the abundance of autumn population and the time lag between the channel rewatering after the dry phase and the sampling date, and with knowledge of spring abundance, we estimated the rate of recolonization in relation to drought duration and extent in four subsequent seasons. The data comparison of intermittent and permanent streams from the same geographical regions can help quantify direct impact of drought that will probably strongly affect stream communities in Central Europe with increasing frequency.

DO MACROINVERTEBRATES RESPOND DIFFERENT TO NATURAL AND ANTHROPOGENIC DISTURBANCES?

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Freshwater ecosystems are subjected to natural (e.g. floods and drying events) and anthropogenic disturbances (e.g. pollution, land use changes, water extraction, or biological invasions). In comparison to human-driven disturbances, natural disturbances have been acting through longer evolutionary times and have triggered particular evolutionary strategies. Given that future scenarios indicate that these natural and anthropogenic events will be intensified specially in some areas, such as the Mediterranean climate regions, there is an urgent need to disentangle the effects of both disturbances and to know if the observed patterns are comparable across regions. We compared macroinvertebrates from reference and human-impacted perennial and intermittent rivers (PRs and IRs, respectively) between the Mediterranean climate regions of Catalonia and Chile using both a taxonomic and trait-based approach. In total, 10 rivers were sampled in Catalonia and 11 in Chile. Results indicated that human disturbances had a stronger effect on taxonomic and trait composition than flow intermittence, homogenizing macroinvertebrate communities in both regions. Macroinvertebrate responses to flow intermittence differed between regions when considering taxonomic composition but similar trait responses were observed. For example, IRs in both regions had a higher proportion of large body sizes, aerial respiration, or multivoltinism, all traits known to be related to flow intermittence. When both disturbance types were present simultaneously, communities were more similar to those found under human-disturbance than under flow intermittence. Our results indicate that there is more convergence between regions due to anthropogenic disturbances than to flow intermittence for both taxonomy and biological traits. Under global change in Mediterranean climate rivers, human disturbances will homogenize biological communities to a larger extent than natural disturbances regardless the region considered.

VANISHING RIVERS IN THE GREAT PLAINS: WHAT CAN BE DONE TO HALT THE RAPID DECLINE IN AQUATIC BIODIVERSITY

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Groundwater pumping for agriculture combined with habitat fragmentation by dams interact to reduce the biological diversity in freshwater ecosystems around the world. Many naturally flowing perennial rivers are being transformed into smaller, intermittent streams and the fish communities are becoming dominated by species with traits that allow them to persist in small, fragmented habitats. In this paper, we quantify the transformation of fish communities in rivers in the Great Plains, U.S.A. and illustrate the importance of dispersal and recolonization in two intensively studied prairie streams in central Kansas. At a regional scale, the greatest declines have been for lotic specialists that require large unfragmented reaches of river to accommodate an obligate phase of drifting eggs and larvae. Additionally, large river specialists are being replaced with taxa that historically occurred in streams of much smaller size. Long-term data from two intermittent prairie streams illustrate the dynamic nature of small streams of the region and the ability of native species to rapidly colonize ephemeral reaches following drought. We propose that species adapted to tolerate ephemeral prairie streams are likely to expand their distribution as large perennial rivers are converted to ephemeral systems. Because it is difficult to halt or reverse groundwater declines, restoration efforts should focus on eliminating barriers and reintroduction of extirpated populations.

ENVIRONMENTAL HETEROGENEITY OF INTERMITTENT RIVERBEDS DURING THE DRY PHASE INCREASES LEAF LITTER DECOMPOSITION DURING THE AQUATIC PHASE

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In many intermittent rivers the dry phase is associated with large amounts of leaf litter accumulating in a great variety of habitats, e.g. open, sun-exposed zones or isolated, stagnant pools. This diversity of environmental conditions promotes various changes in the chemical quality of leaf litter. At later rewetting, large amounts of leaves with very diverse preconditioning histories are mixed and transported downstream, where they are an important resource for decomposer communities.

Here, we investigate whether the high diversity of preconditioning situations of leaf litter typically found in intermittent riverbeds during the dry phase has implications for its subsequent aquatic decomposition. We hypothesize that the mixing of differently preconditioned leaf litter will cause non-additive effects on its decomposition that cannot be predicted from decomposition rates of individual mixture fractions. We addressed this question by (1) preconditioning leaf litter under various controlled laboratory settings, (2) combining preconditioned leaves to make mixtures of increasing diversity, and (3) measuring their decomposition by microbes and shredders in a perennial stream. Our results show positive, non-additive effects on microbial respiration, suggesting complementarity among resource fractions, for instance by transfer of nutrients or labile C compounds. However, we find negative, non-additive effects on shredder biomass, probably due to the hindrance to access to high-quality resources through less preferred litter fractions in mixtures. Unique features of intermittent river functioning, such as this complex effect of chemical diversity on aquatic decomposition, present new challenges for future C cycling models that should integrate intermittent rivers in larger scale modelling efforts.

HOW INTENSITY AND FREQUENCY OF FLOW INTERMITTENCY AFFECT ORGANIC MATTER DECOMPOSITION IN THE SURFACE AND SUBSURFACE WATER IN MEDITERRANEAN STREAMS?

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Climate change predicts a greater frequency of extreme events, including longer and more severe droughts that are expected to alter the hydrological regime in rivers, being the Mediterranean areas especially vulnerable. The decomposition of organic matter plays a fundamental role in ecosystem functioning. However, the consequences of flow alteration in this process due to climate change are highly uncertain. In this sense, the aim of this study is to analyse to which extent the intensity and frequency of flow intermittency affects the decomposition rate of organic matter in the subsurface (15 cm below stream bed) and surface water. To achieve this aim, wood sticks are placed for one year in the subsurface and surface water in 20 streams (with different intensity and frequency of flow intermittency) across Catalonia (NE Spain) to test the following hypotheses: (I) the decomposition rate in stream surface water are determined by the intensity and frequency of the flow intermittency; and (II) the decomposition rate in ephemeral rivers are faster in the subsurface water than in the stream surface water due to the fact that groundwater flow keeps humidity for a longer period of time. The results of this study will allow an ecological understanding to predict the effect of climatic change on ecosystem functioning in Mediterranean streams.

PONDING IN TEMPORARY STREAMS: A REFUGE FOR LOTIC TAXA AND HABITAT FOR NEWLY COLONISING TAXA?

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Intermittent rivers are temporally dynamic systems, shifting between lotic, lentic and terrestrial habitat phases. However, ecological studies have typically focused on the lotic phase and little is known about the contribution of river bed ponding (lentic habitat phase) to biological diversity among intermittent rivers. This paper examines whether river bed ponding provides a refuge for lotic taxa during stream desiccation or is a habitat for newly colonising taxa. We also assessed the contribution of river bed ponding to total aquatic macroinvertebrate diversity. Macroinvertebrate data was collected along 4 intermittent reaches of a temperate river system (River Hamps and River Manifold) in the UK during lotic and ponding phases. A total of 17 temporary ponds were examined. Preliminary results indicate that communities present during river bed ponding were heterogeneous compared to lotic communities and made a significant contribution to overall aquatic diversity. Examining biological communities present during the lentic phase can (1) add significant detail to the ecological functioning of intermittent rivers, and (2) better quantify the overall aquatic biodiversity and conservation value of intermittent rivers in temperate landscapes.

NOACQUA PROJECT: COMMUNITY RESPONSES AND ECOSYSTEM PROCESSES IN INTERMITTENT STREAMS OF NORTHERN ITALY

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The ecology of intermittent rivers (IR) is poorly known and it has recently gained attention in Europe as a key issue for the management of running water ecosystems. Despite Italy is climatically prone to host a large number of IR, studies on such ecosystems are lacking. This is especially true in Northern Italy, where the combined effect of climate change and water abstraction has led to an increase of length and extent of dry phases in IR. The NOACQUA project funded by the Italian Ministry of Education, University and Research aims at studying the multiple effects of hydrologic intermittence on biotic communities, organic matter decomposition and biogeochemical cycles in low order mountain streams of Alps and Apennines of Northwest Italy. Irrigation canals of the Eastern Po Plain will also be studied since they host specialized biotic communities, provide important ecosystem services and generally dry up during winter. Each area will be characterized for taxonomic and functional diversity of diatoms, macrophytes, macroinvertebrates and fish. The potential role of hyporheic zone as a refugium for invertebrate assemblages will be investigated by comparing both intermittent and perennial streams. Decomposition rates of organic matter will be studied with the litter bag technique. At the same time, the speciation and fluxes of nitrogen, phosphorous and silica will be studied both in the field and microcosm incubations. The results of NOACQUA project is expected to contribute a scientific support to the management and monitoring of IR in temperate regions subjected to increasing water scarcity.

SEDIMENT ROUGHNESS AND MOISTURE AS KEY FACTORS FOR STREAM BENTHIC MACROINVERTEBRATES RESISTANCE DURING THE DROUGHT PERIOD

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Hydrological regime of many small streams is significantly altered by human activities or climate change, which can result in a complete dry-out mostly during the summer season. While some of the taxa do not survive, other can resist the disturbance within wet streambed. Macroinvertebrate taxa that are able to penetrate into wet substrate or have specific adaptations for resistance in wet stream bed can survive on a site impacted by drought. The key factors affecting taxa survival is substrate roughness and its moisture.
Desiccation resistance of selected (model) macroinvertebrate taxa (Gammarus fossarum, Ephemera danica, Baetis sp., Pisidium sp. and Oligochaeta (mixture of Limnodrilus/Tubifex sp.) was tested in a laboratory experiment. The main aim of the study was to test the ability of the taxa to penetrate the substrate and the length of their possible survival there. We used three substrate types with different grain size (2-4 mm, 7-10 mm and 20-32 mm), under 7 cm layer of the substrate there was 3 cm layer of permanently watered sand that simulated aquatic refugium (hyporheal). We made five subsequent controls during a period of 32 days from the beginning of the experiment. Soil moisture, air temperature and humidity were measured during the experiment.
Aquatic Oligochaetes and Pisidium sp. showed the best ability to get into wet substrate and survive there for a long period. On the contrary, Baetis sp. could not survive even in wet refugium. G. fossarum and E. danica revealed various abilities depending on the substrate type.

PATTERNS OF PRECIPITATION INTERMITTENCY IN SOUTHERN PORTUGAL: IMPLICATION FOR THE CONSERVATION AND MANAGEMENT OF MEDITERRANEAN INTERMITTENT RIVERS

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Southern Portugal is a semi-arid region, characterized by an irregular spatio-temporal distribution of the precipitation that directly influences the superficial runoff. This variability, together with the occurrence of more or less extended periods of drought, often leads to situations of water stress, negatively affecting freshwater ecosystems. Human activities, particularly those associated with land use, have further aggravated this situation. Medium-small temporary streams are especially affected, as these systems are reduced to isolated pools during dry periods, where the aquatic biota persists until the following wet season. Moreover, the effect of dryness can be seriously amplified in the future, considering the foreseen climate change scenarios. Therefore, the main goal of this study was to define regions of hydroclimatic intermittence in southern Portugal based on the pattern of precipitation intermittency. Long time series of precipitation data were collected from 9 meteorological stations covering the south of Portugal region. Data analysis involved the selection of metrics and the development of intermittence indices, based on the precipitation patterns for control and future periods. Regions of hydroclimatic intermittence were displayed in a GIS environment, allowing the evaluation/classification of the persistence level of southern Portuguese streams and rivers for present and future periods. The relationships between the persistence level of streams and the long term viability of freshwater biota are discussed. The definition of regions of hydroclimatic intermittence can be a useful tool for water management in Mediterranean intermittent rivers.

INVERTEBRATE DIVERSITY AND COMPOSITIONAL CHANGES WITHIN MULTIPLE WET-DRY CYCLES IN A TEMPORARY STREAM

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Seasonal drying is a key driver of invertebrate diversity and community composition, and modifies resource fluxes and habitat conditions. Flow expansion and contraction cycles may alter downstream invertebrate distributions and the spatial arrangement, temporal turnover and connectivity of physical habitats. Previous ecological work has typically examined invertebrate distributions to physical/chemical gradients in intermittent rivers. However, less is known how the frequency and duration of mid-reach drying impacts diversity and community composition between perennial upstream and downstream reaches within multiple wet-dry cycles. This study examined the spatial variation in species composition (β diversity) between perennial reaches caused by mid-reach drying. We compared the structure and composition of benthic invertebrates in short (4-6 weeks) multiple wet-dry cycles in a temperate UK catchment. Benthic invertebrates were collected at four intermittent and three perennial reaches over 1 year. Reaches were sampled at 1-2 month intervals between May and October 2016, and in April 2017 (six sampling dates). Initial results indicate invertebrate heterogeneity varies between perennial reaches, and between intermittent and perennial reaches throughout wet-dry cycles. Understanding the impact of seasonal drying to biodiversity patterns at the catchment scale is increasingly important given predicted changes in climate, the need for biomonitoring of intermittent rivers, and the desire to advance understanding in river and landscape ecology.

CHANGES IN FOOD-WEB STRUCTURE IN RESPONSE TO RIVER REGULATION

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Flow regime is a major influence of community composition and structure in riverine ecosystems, and flow regulation by dams often induces artificially-stable flow regimes downstream. This represents a major source of hydrological alteration, particularly in regions where biotas are adapted to a strong seasonal and interannual flow variability. Although the effects of flow regulation by dams on populations and communities have long been studied, less research has been devoted to understanding responses at higher levels of organization. Because environmental variation is a major determinant of food-web structure in rivers (dynamic stability hypothesis), we predicted that dam-induced hydrological stability should alter the strength and distribution of food-web interactions. We tested this prediction in a highly seasonal Mediterranean river affected by a dam for irrigation, by comparing an unregulated reach to several reaches downstream of the dam. The dam increased hydrological and sedimentological stability, and altered the type and quantity of available resources. This prompted a change from a detritus-based to an algal-based food web becoming the food web wider and longer downstream of the dam. Food-web structure did not recover 14 km downstream of the dam despite a partial restitution of the flow regime, as shown by a combination of network metrics. Our results advance the notion that riverine food webs may change in structure in response to hydrologic alteration not only via additions/deletions of taxa (i.e., local extinctions and invasions), but also via shifts in the strength and distribution of food-web interactions.

GRAZING AND DRYING INTENSITY MODULATE DROUGHT RESISTANCE AND RECOVERY OF STREAM BIOFILM RESPIRATION

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Climate change is predicted to cause increase of droughts and shift of low order perennial to ephemeral streams in temperate regions. Drying of bed sediments as known from Mediterranean regions will be consequence. However, since temperate streams are well canopied and summer temperature are lower compared to Mediterranean, the drying intensity will be more benign. e. g. by remaining high humidity in sediment pore space. In a microcosm experiment we investigated the functional response of a temperate hyporheic biofilm with and without invertebrate grazer to four weeks of drying-up. We applied two drying intensities: benign and harsh (90% respectively 30% humidity in the interstitial gas phase). Presence of grazers increased microbial respiration (mCR) before drying. Immediately after the water was drained from the pore space mCR dropped severely. The remaining mCR and its exponential decrease during drying was modulated by drying intensity and grazer presence. Grazer mortality was 50% in benign and 100% in harsh drying. The recovery was faster after benign than after harsh drying (4h respectively 30h). The degree of recovery after rewet was about 65% of the mCR in the treatments without grazers; with grazer it was 40% after harsh and 24% after benign drying compared to permanent stream water perfused controls. Findings show that intensity of drying and interaction with grazer modulate the functional resistance and recovery of stream sediment biofilms and underline the complexity of the mechanisms that determine metabolic resilience and recovery to and from supra-seasonal drought.

DIATOMS AND GROUND BEETLES (COLEOPTERA: CARABIDAE) IN INTERMITTENT AND PERMANENT RIVERS IN MONCHIQUE MOUNTAINS (SOUTHERN PORTUGAL)

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The importance of intermittent watercourses is widely recognized, as they represent a great part of the river network worldwide. This is also the case of Portugal, where it is estimated that more than 80% of the territory is drained by intermittent rivers. Given their importance, a study with benthic diatoms and ground beetles (Coleopteran: Carabidae) was carried out to understand their value as bioindicators in intermittent and permanent rivers. To do so, benthic diatoms were sampled in Spring and ground beetles in Spring and Summer 2006 and 2007 in reference sites in Monchique, a mountainous area located in the Algarve region, Southern Portugal, mostly classified as part of EU ecological network Natura 2000 (Directives 79/409/EEC and 92/43/EEC). Preliminary results showed that benthic diatom communities differ between the two river types, with intermittent watercourses characterized by higher taxa richness (S), Shannon index of diversity (H') and Pielou's evenness index (J'). Indicator value analysis revealed that Amphora pediculus, Cocconeis lineata, Eolimna minima, Gomphonema pumilum, Melosira varians C. Agardh, Navicula gregaria and Sellaphora seminulum are indicators of the intermittent watercourses in this area.
Concerning ground beetles the difference between the two river types was not significant. However, some species were present in a more consistent way in permanent streams (Perileptus areolatus and Trechus obtusus), and others were more frequent in intermittent streams (Agonum muelleri and Anisodactylus hispanicus). In the intermittent streams, along the dry summer phase, the species frequently present, with hydrophilic characteristics, were Paranchus albipes, Stenolophus skrimshiranus, Bembidion decorum and Bembidion coeruleum.

USABILITY OF BIODROUGHT METHOD FOR BIOINDICATION OF STREAM INTERMITTENCY ON WIDER GEOGRAPHICAL SCALE

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More frequent episodes of complete or partial drying of streambeds have been recorded during last decades in almost all Central European countries. The stream intermittency may have serious ecological and economic consequences depending on the frequency and duration of dry periods, and it raised an increasing demand for proper identification and classification of this phenomenon. Conventional hydrological techniques are expensive and unpractical when hundreds of small stream have to be monitored on large scale – e.g. big river basin or whole country. During the BIODROUGHT project (biodrought.eu) we developed an alternative tool for retrospective detection of dry episodes, which were defined as flow cessation in a monitored stretch. The method, which is based on macroinvertebrate community analyses, was developed in the Czech Republic and calibrated for small-sized, near-pristine streams (up to 4th Strahler order, altitude 200-500 m). It uses a multimetric index based on taxonomic-functional composition and indicator taxa, and enables the classification of streams into three groups: permanent (continual flow all year), vulnerable (dry period < 10 days per year), and intermittent (dry period > 10 days per year). To test the usability of this method on a wider spatial/geographical scale we gathered independent samples from the Czech Republic and also from the model sites in Mecsek Mountains in Hungary. The results show good potential for extensive usage of this method, although for wider geographical application it has to be adapted for regional fauna and available taxonomic resolution commonly used for monitoring in a target country.

THE NOVEL TOOL FOR BIOINDICATION OF THE DRY EPISODE IN SMALL STREAMS – CZECH BIODROUGHT METHOD

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The ongoing climate change results in more frequent hydrological extremes. Complete or partial drying of small water courses had become a relatively common phenomenon in the Czech Republic and the need for a tool for assessing the drought impacts on aquatic environment emerged. A novel method for bioindication of dry episodes in Czech streams and small rivers (up to 4th order according to Strahler) was one of the main outcomes of the past project BIODROUGHT (www.biodrought.eu). It is a retrospective method indicating dry episodes which occurred during the previous vegetative season, and it is based on the analysis of taxonomic and functional composition of benthic macroinvertebrate communities (BIODROUGHT index).

This poster presents: i) an approach to the discrimination of invertebrate communities influenced by different levels of drought impact (i.e. no impact, slight impact and marked impact), ii) a success rate of drought indication using independent samples taken by routine monitoring, and iii) the available tools for calculating BIODROUGHT multimetric index.

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FIRST FLUSH PULSES OF NUTRIENTS AND ORGANIC MATTER IN DRY RIVERS WORLDWIDE

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Intermittent rivers and ephemeral streams (IRES) function as pulsed biogeochemical reactors, releasing nutrients and organic matter during rewetting. However, we are still lacking a general understanding of the biogeochemical functioning of IR, and their contribution to the nutrient and carbon loads at the river network and landscape scales.

We conducted a laboratory study to simulate rewetting events and assess composition of leachates from leaves, biofilms and sediments collected from 210 IRES through the “1000 Intermittent rivers project” (http://1000_intermittent_rivers_project.irstea.fr/) along a gradient of climatic zones. Leachates were analyzed for concentrations of nutrients readily bioavailable for plants and microbes, concentration of 3 major sub-fractions of dissolved organic matter and aromaticity.

The highest release rates of major nutrients from sediments and leaves were observed in IRES located in the continental climatic zone. There, the concentrations of dissolved organic carbon and soluble reactive phosphorus released from the sediments were significantly higher compared to the sediments from temperate, tropical and arid regions. For leaves, significantly higher concentrations were found only for ammonium in the continental zone. In most cases, the lowest release rates were observed from leaves and sediments collected in arid zones; however, leachates from this zone were characterized by a higher potential biodegradability (based on aromaticity) compared to other zones.

Subsequent studies have to reveal impact of local environmental factors on biochemical composition of substrates and subsequent fluxes of organic matter in IRES affected by dry-wet cycles. A general approach to incorporate IRES in nutrient load models needs to be developed as well.

SURVIVAL OF AQUATIC INVERTEBRATES IN STREAMBED SEDIMENTS OF INTERMITTENT STREAMS WITH DIFFERENT DURATION OF DRY-PHASE

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Complete loss of surface water flow is a regular event in intermittent streams. This flow cessation is harsh ecological disturbance for aquatic biota, yet a lot of benthic invertebrates can be found in such streams in relatively short period after reflooding. There are two mechanisms of species survival in such environment: high resistance or resilience. The resilience is represented by species ability to survive in refuges (pools, permanent reaches, springs) and recolonize reflooded channel. Resistant taxa are able to survive in dry stream sediments and often form specialized resistant stages (e.g. eggs, diapausing larvae, cysts) which are crucial for long term survival. However, some taxa show the ability to survive shorter dry periods without dormant stages.

We examined samples of dry bottom from near-pristine intermittent streams during a summer dry episode when surface water disappeared from their channels. The sediment samples were taken from the surface of stream bottom (maximum depth 15 cm) and at various time after the flow cessation (1 to 90 days). The substrate samples were washed out through the net (mesh size 250 μm) and aquatic invertebrates which were still alive were sorted. Differing ability to survive the dry episode was observed within different taxa groups. Survivors' community composition was compared to the community sampled in wet phase before and after the dry episode to determine which taxa use streambed as a refuge for survival as adults or macroscopic larvae.

NOVEL BIOMONITORS FOR ECOLOGICAL STATUS ASSESSMENTS IN INTERMITTENT RIVERS AND EPHEMERAL STREAMS

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The EU Water Framework Directive requires attainment of 'good ecological status' in all waterbodies, but regulatory biomonitoring typically excludes intermittent rivers and ephemeral streams (IRES), or only characterizes their flowing-phase communities. Classification of IRES ecological status is therefore based on incomplete biotic characterizations, making identification of dry-phase biomonitors a research priority. We present a preliminary examination of multiple potential dry-phase biomonitors, for example: macrophytes, including semi-aquatic vegetation; terrestrial invertebrate assemblages, such as ground beetles; hyporheic invertebrates, including epigean macroinvertebrates; and the 'seedbank' of desiccation-tolerant aquatic invertebrate life-stages that persists within dry-channel sediments. Our results highlight that multiple groups can distinguish between sites with contrasting environmental conditions and therefore have the potential to act as dry-phase biomonitors. Biotic responses were typically specific to particular hydrological, geomorphological, or water quality stressors, highlighting the need for methodologies that incorporate multiple stressor-specific biomonitors. As in flowing phases, co-sensitivity to flow intermittence and ecological status represents a major challenge in IRES dry-phase biomonitoring. Our interpretation of community composition in relation to local environmental conditions is conducted with caution, as sampled communities also reflect connection to wider metacommunities by regional processes such as dispersal capacity. Further research is needed to validate our preliminary identification of potential dry-phase biomonitors; to explore opportunities to complement such taxa-based biomonitoring with trait-based and molecular approaches; to promote incorporation of metacommunity dynamics into IRES biomonitoring; and, ultimately, to develop new multi-metric indices informed by both wet- and dry-phase ecological status assessments.

BIOFILM RESPONSES TO FLOW INTERMITTENCY IN TEMPORARY AND PERMANENT STREAMS: DOES BIOFILM ORIGIN MATTER?

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The proportion of streams experiencing flow intermittency is dramatically increasing due to global change and a better understanding of the vulnerability and resilience of fluvial ecosystems to flow intermittency is needed if we are to predict the effects on biodiversity and biogeochemistry. Plenty of studies have assessed vulnerability and resilience to flow intermittency of biofilms in temporary streams, but little is known of biofilms from permanent streams. In order to determine differences in the vulnerability and resilience to flow intermittency for biofilms in temporary and permanent streams, we performed a laboratory experiment in artificial streams. Stream cobbles with intact biofilm communities were translocated from four temporary and four permanent streams, to artificial channels under the same physical and chemical conditions, where we exposed them to a non flow event of 30 days. Vulnerability and resilience were assessed on biofilm structural (e.g., algal biomass) and functional variables (e.g., community metabolism). Results pointed out that the original source of the biofilm influences the vulnerability and not so much the resilience. Thus, the P:R ratio showed similar resilience patterns, but lower vulnerability in biofilms from temporary streams. These differences could be associated to the higher vulnerability of the autotrophic component from permanent waterways. Overall, results suggest that we might expect differences in vulnerability between permanent and temporary streams within the same geographical region.

MACROINVERTEBRATE RESPONSES TO HYDROLOGICAL CONTROLS AND GROUNDWATER ABSTRACTION PRACTICES IN INTERMITTENT AND PERENNIAL RIVERS

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It is estimated that over half of the world's stream channels dry periodically. Despite this, relatively few studies have examined the biotic implications of hydrological alterations within temporary streams. Within the UK, the chalk aquifer is the most important for public water supply and is subject to more groundwater abstraction activity than any other aquifer. The chalk landscape supports nationally unique intermittent rivers which typically only flow during the winter months; these are regionally called 'winterbournes'. This study quantified the medium-term (5-years) macroinvertebrate community responses to observed hydrological controls and modelled groundwater abstraction influences across intermittent and perennial rivers overlaying chalk regions in the Hampshire Avon catchment (UK). Winterbournes supported macroinvertebrate communities of high conservation value due to the presence of nationally rare aquatic insects, such as Paraleptophlebia werneri (Order: Ephemeroptera). Antecedent flow durations and the distance from the perennial head were found to be key drivers of macroinvertebrate community diversity, while groundwater abstraction had a limited overall effect. Taxonomic richness was the most sensitive community parameter to recorded hydrological conditions. The rate at which taxonomic richness changed was greater when modelled against the distance from the perennial head compared to antecedent flow conditions. The results indicated the distance which fauna could migrate upstream of the perennial head differed between taxa. This will have significant implications for macroinvertebrate communities residing within intermittent rivers through predation and/or increased biotic competition. As such, this research indicates that the length of intermittent rivers is a primary control on winterbourne community composition.

SHADING AND SEDIMENT STRUCTURE MODULATE THE STRUCTURAL AND FUNCTIONAL RESISTANCE AND RESILIENCE OF THE SEDIMENT MICROBIAL COMMUNITY TO SUPRA-SEASONAL DROUGHT

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Drying of isolated stream sediments is reported to impact structure and metabolism of the microbial community. However, the consequences of a drought in the complex environment of a temperate canopied stream with heterogeneous sediment structure and variable light availability are not known. We assessed the impact of a simulated supra-seasonal summer drought in 16 experimental streams that varied in sediment structure (sorted and patched versus homogeneous non-sorted sediments) and shading (low versus highly shaded). The influence of these factors on community structure, community respiration (CR), and net ecosystem production (NEP) was tested in the course of 6 weeks initial colonization, 6 weeks drying, and 2 weeks after flow resumption. During colonization, low shaded streams developed into net autotrophy while highly shaded remained net heterotrophic. Within hours after flow cessation, CR and NEP decreased to low rates whereby the low shaded streams also turned into net heterotrophy. Drying of the stream bed caused further exponential decrease of the community metabolism to almost zero after 20 days. CR rates during drying depended on shading. Following flow resumption, CR peaked within few hours and declined thereafter to level similar to before drying, while NEP recovered slowly. The degree of NEP recovery depended on shading. Sediment structure affected shift of the periphyton community during drying and recovery but surprisingly had no effect on the metabolism. Findings show that despite shift in community composition metabolic function of sediment biofilm is remarkably resilient towards drying and light availability is major factor for its resistance and resilience.

HOW URBAN SYNDROMES AFFECT ORGANIC MATTER PROCESSING IN STREAMS?

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Only limited research has been done on the biotic structure and ecosystem functioning under pressure of human impact in urban, strongly altered streams in Europe. Different urban syndromes such as environmental stressors are responsible for impairment of aquatic systems. We hypothesise that downstream sites of urban streams are more impacted than upstream ones in suburban catchments. Our study focused on the analysis of the main dysfunction symptoms in urban streams (channel and discharge regulations, thermal regime changes, pollution impact, catchment management, and riparian zone modification) and their effects on benthic community functioning and organic matter processing. We will discuss problems related to the most important stressors shaped aquatic communities that arise in degraded aquatic ecosystems.

THE URBAN WATERS RESEARCH NETWORK: VISIONS AND PERSPECTIVES

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The Urban Waters Research Network is a new initiative improving synergies and cooperation between players in the field of urban habitat restoration, biodiversity and ecosystem services. The European Water Framework Directive (WFD) falls short to envisage how to achieve the ecological potential of Heavily Modified Water Bodies (HMWBs) and Artificial Water Bodies (AWBs) in urban environments. While the classical goals of the WFD are valid outside of urban settings, within or adjacent to dense human settlements, the demands of humans for water and nature related ecosystem services overrule the classical goals of the WFD. This makes the public participation in the implementation process of the WFD at least difficult. We review different approaches how to deal with HMWBs & AWBs in urban environments and propose a theoretical framework and concept how to better implement ecosystem services in the assessment of HMWBs & AWBs.

MACROPHYTE DIVERSITY IN RIVERS UNDER VARIOUS HYDROMORPHOLOGICAL PRESSURE

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In our research we hypothesize that high diversity of natural hydromorphological elements and habitat heterogeneity (substrate diversity, flow type, natural features, bank vegetation) resulting in higher alpha and beta diversity of macrophytes. The main aim of the work was to investigate the diversity of macrophytes in rivers under various degrees of hydromorphological alteration. In our analysis 75 sites representing three groups of rivers (unaltered, resectioned and reinforced) were used (25 sites in each group). In each site, the botanical research was conducted based on the Macrophyte Index for Rivers method and hydromorphological assessment was carried out following the River Habitat Survey. Water quality for each river was also analyzed. The results show that α-diversity of macrophytes estimated as the average species richness and Shannon-Wiener index decreases with increasing hydromorphological alteration, while β-diversity (calculated as Jaccard Index) was higher in most modified rivers. The results showed that the natural river habitat (its heterogeneity, diversity) promotes diverse development of macrophytes within river site. These hydromorphological conditions however, do not result in differences in macrophyte composition between river sites, even despite a very large pool of species in this group. Differences in species composition of macrophytes between most modified rivers can result from niches that arise in these altered habitats. This niches, by giving secondary heterogeneity, could be inhabited by various macrophyte species increasing their diversity.

ECOHYDROLOGY FOR REGULATION OF URBAN STORMWATER RUNOFF

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A high percentage of urban impermeable areas prevents the free flow of rainwater, particularly after intensive rainfall. Numerous of floods, inundations and urban ecosystem degradation represent consequences of this state. Moreover, the pollution flushed from impermeable areas are usually drained directly to rivers and reservoirs, which also perform a recreational function in cities. This contributes to a gradual degradation of these aquatic ecosystems and their intensified trophy.

A sequentional stormwater purification system (SSPS) combine with underground separators system, which was constructed under LIFE08 ENV/PL/000517 project, stabilises rainwater runoff from the urban watershed and minimise the flood risk by retention of water in landscape. It is one of the examples of adaptation of the cities to climatic changes by ecohydrology approach (LIFE14 CCA/PL/000101). It also effectively reduces the pollution introduced to surface water with rainfall, which ultimately limits the problem of toxic cyanobacterial blooms formation. The studies demonstrated that the SSPS reduces the total phosphorus (TP) and total nitrogen (TN) at the inflow to the SSPS from the average concentration reaching 3,18 mg/l and 5,61 mg/l up to 0,75 mg/l and 1,35 mg/l respectively at the outflow of water from SSPS to the river. The average concentration of these two parameters in the river above the SSPS was equal or higher than these values and reached 0,74 mg/l and 1,63 mg/l respectively. The system removes 90,0% of suspended matter, 75,9% of TN, 76,4% of TP, and from 47,5% to 74,2% of other nutrients transported with rainwater from streets to rivers.

POWER GRID VS AQUATIC ORGANISMS: LABORATORY EMULATION

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Europe is one of the largest continuously urbanized areas of the world. To facilitate our urban needs and make our lives easier we almost fully rely on electricity and to get it we construct power generation, transmission, and distribution systems. This human activity is among the fastest growing environmental pressures in Europe today. Our interest in this study was in the effects of the electric fields created by the transmission, and distribution systems. Of course, electromagnetic fields are also naturally generated by the Earth and surrounding universe and since we are still here it is clear that the living world is well adapted to these natural sources. Earth produces relatively strong magnetic field while electrically Earth is practically inert. That is why we focused our study on the electric fields constructing a plate capacitor to emulate electric field stress that can be observed near power grid system. We exposed two aquatic protist species (Paramecium caudatum and Euglena viridis) to a range of strengths of electric fields. Exposure to electric fields resulted in decrease of population and in increase in stress enzyme activity in both species. In addition, individuals exposed to electric field changed in morphology, decreasing in size perpendicular to their fission plane.

IDENTIFYING THE JOINT EFFECTS OF FLOW INTERMITTENCY AND URBAN WASTEWATER ON MEDITERRANEAN STREAM COMMUNITIES

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Under natural conditions, Mediterranean rivers show strong annual and interannual hydrological variations with marked flow reduction in summer. These rivers may receive urban wastewater effluents, which constitute a source of nutrients, organic matter and emerging contaminants. In many instances, these effluents convert temporary streams into permanent, affecting the biological communities they host. Our aim was to establish the effect of urban wastewater on freshwater invertebrate communities in Mediterranean rivers from a taxonomic and functional point of view, and to identify the potential synergistic role of flow intermittency. We therefore sampled twelve sites in different hydrological periods (summer and autumn 2015, spring 2016). In each site we defined a control reach upstream from the effluent input and an impact reach downstream. Non-random taxa loss occurred in the impact sites: both the abundance and biomass of tolerant taxa increased while taxonomic diversity decreased. Filter-feeders and predators increased at the impact sites, where also dominated taxa with life cycles longer than one year, and increased the proportion of organisms with aerial respiration. Our study revealed strong selection of functional traits in relation to the severity of both impacts.

ASSESSING THE INTERACTIVE EFFECTS OF URBAN POLLUTION AND WATER SCARCITY ON THE FUNCTIONING OF MEDITERRANEAN STREAM ECOSYSTEMS

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Pollution has become one of the most important stress factors in river ecosystems of urban areas. These systems may also be affected by water scarcity, which determines the dilution capacity and affects the concentration of pollutants. We evaluated the interactive effects between urban effluents and water scarcity on river ecosystem functioning. We analysed the response of different processes (organic matter decomposition, nutrient uptake and whole-stream metabolism) into 13 streams arranged in a gradient of water scarcity in the Ebro River basin, where reaches downstream (impact) received urban sewage inputs, while those upstream were used as a control. Results show diverging responses among the measured ecosystem processes. Sewage inputs, either treated or untreated, tended to subsidize organic matter decomposition except at the most polluted sites, where we detected evidences of a stress effect. On the contrary, biofilms showed reduced capacity to uptake phosphorus, and reach-scale retention was also reduced. Metabolism was strongly affected below sewage inputs, causing severe anoxia in the most polluted reaches. Overall, results point to a complex response of stream ecosystem functioning to urban pollution, which depends, among others, on the treated or untreated characteristics of the effluent and on the dilution capacity of the receiving water body, which is reduced in periods of water scarcity.

STREAM FOOD-WEB CHANGES ALONG MULTIPLE GRADIENTS OF URBAN STRESS

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With the aim to enhance our understanding of the structure and functioning of urban stream ecosystems, we investigated two low-order urban streams in Zagreb, Croatia. The headwater (reference) sites of each stream were located in the Nature Park, whereas middle and lower stream sites were aligned along a gradient of urban disturbance within the city center. We measured and analyzed: (i) key water quality parameters and 28 metal/metalloid concentrations; (ii) composition of periphytic- and meio-fauna; (iii) distribution of macrozoobenthos and particulate organic matter in benthos and drift; and (iv) food-web structure of the streams. We found that the urbanization gradient, amounts of nutrients, dissolved organic matter and metals/metalloids in water altered the community structure across the study sites. In comparison to the headwater sites, the more urbanized sites had more abundant and diverse macrozoobenthic-, periphytic- and meio-fauna dominated by eurivalent taxa, but lacking the less tolerant species. Urbanized sites had higher macroinvertebrate drift density and diversity dominated by Amphipoda, Ephemeroptera and Diptera and reduced particulate organic matter in benthos and drift. Using carbon (δ13C) and nitrogen (δ15N) stable isotope analysis we also detected shifts in macroinvertebrate food sourcing, indicating that macrozoobenthic taxa change their feeding habits with increased urbanization. Our findings demonstrate the dynamic nature and sensitivity of low-order stream communities along the gradients of urban influence. These streams require comprehensive further research to enable more effective management strategies.

WATER QUALITY AND POLLUTION BY HAZARDOUS SUBSTANCES OF A SMALL LOWLAND STREAM UNDER DIFFERENT HYDROLOGICAL CONDITIONS

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This study investigates water quality and hazardous substances toxic to aquatic life in a small lowland stream under different hydrological conditions. The objective was to explore links among hydrology, water chemistry and microbial contamination in a stream predominantly impacted by structural degradation of stream morphology (channelization and straightening), agricultural land use in the catchment, and by a high load of treated wastewater. Sampling was carried out during spring high (HWL, > 200 cm), summer low (LWL, <100 cm), and autumn and winter medium (MWL, 100-200 cm) water levels at seven sites exposed to distinct pollution level. The results showed that water quality decreases in correspondence of stream segments receiving the critical amount of wastewaters and runoff from the surrounding agricultural area. Organochlorine pesticides (OCP), hexachlorocyclohexanes (HCHs) and DDT and its derivatives were measured in 96%, 88% and 38% of water samples. Three to six time higher concentrations of OCP than water quality standards were determined in autumn (MWL) due to leaching from the surrounding agricultural area. Extremely high values of faecal streptococci, intestinal enterococci, and Escherichia coli were found at sites downstream of the municipal wastewater discharge during spring (HWL) and autumn (MWL), most probably because of an inefficient urban sewage treatment and a significant amount of precipitation in a relatively short time before sampling. Traditionally, legislation has been focusing on controlling emissions from point sources. However, our results show that this focus needs to expand on controlling emissions from diffuse sources, such as the agricultural use of fertilizers and pesticides.

MAPPING DISSOLVED ORGANIC MATTER DIVERSITY ACROSS BERLIN´S AQUASCAPE

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Water bodies in urban areas are typically highly modified and stressed systems, which receive large loads of nutrients, organic carbon and pollutants such as heavy metals and pharmaceuticals. However, urban areas also include less affected ecosystems often maintained for recreation. In fact, the urban aquatic landscape is a mosaic of contrasting subsystems that can be considered a meta-ecosystem. The associated high heterogeneity of urban water bodies provides a rare opportunity to understand landscape-scale ecosystem functioning. We used dissolved organic matter (DOM), which has been poorly studied in urban aquatic ecosystems, as a chemically complex indicator of fundamental ecosystem processes. Our rationale was that spatially autocorrelated urban factors such as nutrients, pharmaceuticals and heavy metals control ecosystem processes such as respiration and primary production, which in turn determine the quality of DOM of urban aquatic ecosystems. Thirty-two randomly selected sites in the city of Berlin, including lakes, ponds, streams and rivers, were sampled seasonally over one year. We measured DOM aromaticity and water colour, fluorescence (for PARAFAC modeling), and molecular size distribution by liquid size-exclusion chromatography in combination with UV and IR-organic carbon detection and UV-organic nitrogen detection (LC-OCD-OND). We view such spatially resolved data on DOM composition and diversity as an aquatic meta-ecosystem´s signature (metabolome), which we intend to use for the characterization of aquatic ecosystem carbon dynamics of large cities, which are becoming an ever more dominant type of land cover worldwide.

THE EFFECT OF DESICCATION EVENTS ON THE PHOSPHORUS ADSORPTION OF FLOODPLAIN SEDIMENTS AND THE CONTRIBUTION OF THE MICROBIAL COMMUNITY TO THE PHOSPHORUS UP-TAKE

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Large river floodplain systems play a key role in the transport, transformation and storage of nutrients, especially phosphorus. The introduced phosphorus is either subject to short-term storage mediated by plants and algae or to long-term storage mediated by sediment deposition or adsorption. Sorption–desorption processes within the sediment are influenced by the mineral composition of the sediment, microbial activity and dry-wet cycles. Due to major changes such as climate change, human alteration of flow regime and land use, the hydrology of riverine floodplains can be altered. This can lead to longer dry periods in the floodplain which may also alter the sorption and desorption processes. The present study was conducted to evaluate the impact of drying on the adsorption capacity of two different floodplain sediment types (different grain size and organic content) and the contribution of the microbial community to the phosphorus up-take. Core samples were collected at two different connected sites in the Danube floodplain area “Untere Lobau”, east of Vienna. Sediment characteristics (nutrient content, organic content, grain size) were analysed and after two desiccation periods (10 and 20 days) phosphorus adsorption capacity was measured with gamma sterilized sediment to exclude microbial activity and with untreated sediment (with microbial activity). The presentation wants to give an overview on the first results of this laboratory experiment and the conclusions which can be drawn for restoration measures.

THE ROLE OF WATER MOVEMENT ON NUTRIENT FLUXES BETWEEN WATER AND SEDIMENTS AT RESERVOIRS

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Reservoir eutrophication is normally controlled by nutrient availability in the water column, with phosphorus (P) usually being the most critical compound regarding primary production. Despite the external load of nutrients, which comes from the inlet flow, its availability in the water can also be a function of its release/sink from sediments (known as the internal load). However, internal load rates considered for biogeochemical ecological models are still far from reality. P exchange in the water-sediment interface depends on several factors, such as temperature, pH, redox potential, dissolved oxygen, and biological activity; which had been widely studied. These fluxes are typically described by the Fick's law of diffusive transport. Advection, however, is rarely taken into account. Moreover, we argue that during floods or reservoir's gates/valves operation, the water velocity and turbulence can be high enough to significantly enhance those P fluxes. Thus, considering the high complexity of small-scale turbulence above the reservoir bottom, water movement likely is a factor missing in our understanding of such nutrient fluxes. Hence, our research aims to describe the role of water movement on this process. We started characterizing continuous-tracer concentration profiles developed in a lab-created water-sediment interface under different hydraulic conditions. Hydrodynamic properties were described using Acoustic Doppler Velocimetry (ADV), while concentration profiles were addressed through conductivity measurements. Even though results are in a preliminary stage, they provide enough evidence that water movement plays a key role in the flux of P from the sediments and, thus, this topic warrants a more detailed investigation

NITRATE INFLUENCE ON PHOSPHORUS RELEASE FROM LAKE SEDIMENTS

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A decrease in nitrate concentrations may promote phosphorus (P) release from those lake sediments that are sensitive to oxidation. This may have adverse effects on water quality especially in shallow lakes. We studied the effect of nitrate availability on sediment P uptake and release for varying Fe contents and under oxic and anoxic conditions by means of lab experiments, benthic chamber in situ measurements and mathematical modelling. The focus was put on low nitrate concentrations (< 2 mg l-1) typically found in German shallow lakes.

Nitrate control on P release was found to be weak in most cases. This can be attributed to low nitrate availability in productive lakes, the predominant role of oxygen in Fe oxidation, a lack in available Fe, or significant anoxic P storage capacity. At moderate Fe availability, nitrate can substitute oxygen and thus delay sediment P release during temporal stratification in shallow lakes. However, due to limited availability and high consumption of nitrate, this is a temporary effect.

P uptake of iron rich sediments was found to be largely independent of redox conditions and nitrate levels. Nitrate may even disturb the formation of vivianite and thus the long term P accumulation in anoxic sediments. Our studies also confirm the adverse effect of Fe immobilization in sulfide form. We propose that the management of shallow lakes should be targeted at high Fe availability by means of eutrophication control and minimization of sulfate immission.

IMPORTANCE OF VIVIANITE FORMATION FOR LONG TERM PHOSPHORUS RETENTION IN AN URBAN LAKE (LAKE TEGEL, GERMANY)

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Since the retention of phosphorus (P) in lake sediments controls its availability in the water, it is often a target parameter of internal management measures. We studied the impact of anthropogenic activities over one century on the mechanisms of P retention in sediments by combining chemical analysis of dated sediments with laboratory experiments and long-term monitoring data. The sediment stratigraphy reflects the recovery of the lake after high loadings with nutrients and heavy metals originating from the discharge of irrigation fields and untreated sewage from the beginning of the 1950s. The P retention was lower during the period of severe eutrophication and is now gradually converging values of the beginning of last century. The higher P retention before and after the eutrophication period is associated with the occurrence of vivianite, a reduced iron(II) phosphate mineral in the corresponding sediment layers. Vivianite bearing layers are characterised by a molar S:Fe ratio >1.0, and a distinct higher portion of the NaOH extractable SRP. In recent years, the observed transfer of P bound to reducible iron (BD-P) to NaOH-SRP is a strong indication that vivianite is forming during early diagenesis. Laboratory experiments have shown that a higher redox potential (nitrate addition) stimulated the temporary P binding to oxidized Fe at the sediment surface. However these conditions prevented the possible formation of vivianite by keeping the iron oxidized. Consequently, the vivianite authigenesis as a permanent P sink can be managed by the addition of iron and/or by lower sulfur supply by lowering the productivity.

EFFECT OF TERMINAL ELECTRON ACCEPTORS (TEAS) ON BIOGEOCHEMISTRY OF THE SEDIMENT WATER INTERFACE AND PHOSPHORUS CYCLE

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The inflow parts of eutrophic reservoirs typically exhibit exacerbated rates of primary production, with concomitant increases in organic sedimentation and detrimental effects to water quality. Organic matter remineralization demands energetically favourable terminal electron acceptors (TEAs), which lead to depletion of dissolved oxygen (O2) and nitrite (NO3-). The dissolved concentrations of these and other TEAs also change seasonally across longitudinal water level gradients. Here we evaluate the biogeochemical consequences associated with such shifts and its effects over phosphorus (P) cycling at the sediment-water interface. A laboratory mesocosm experiment was conducted using sediment from the “transitional zone” of the Vranov Reservoir, Czech Republic, which exhibits significant seasonal changes in TEAs availability. The sediments were incubated during five weeks in three parallel variations that simulated (i) shifts from O2-saturated water column in the presence of high concentrations of NO3-; (ii) oxic water with depleted NO3-; and (iii) anoxia with exhausted NO3-. Our combined dataset includes weekly sediment pore water chemical analyses with an improved DET technique (diffusive equilibrium in thin film) for the whole incubation period and three times a week chemical analyses of the water above the sediment. Speciation of phosphorus and metals using different sequential extraction techniques, acid volatile sulfur extraction, in situ synchrotron-based mineralogical identification, and sediment DNA extraction allowed assessing changes in the sediment behaviour and the role of key microbial respiration pathways. Our multi-analytical approach indicate critical changes in remineralization reactions coupled with TEA consumption, and point to a critical role of Fe-based metabolisms in P solubilization.

THE FATE OF ORGANIC MATTER IN FRESHWATER SEDIMENTS; A CLUE TO PHOSPHORUS IMMOBILIZATION?

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Organic matter (OM) in freshwater ecosystems exerts a key role in the global carbon, nitrogen, iron and phosphorus cycles. The burial of OM also plays a major role in retaining bioactive metals that can also drive a plethora of benthic biogeochemical processes in continental sediments. As OM is deposited, the interaction of microbes and nutrients leads to authigenic mineral precipitation and transformation that drive the sorption/desorption of phosphorus (P), which is a limiting factor controlling eutrophication in freshwater systems. The release of P in freshwater is largely attributed to the desorption from reactive iron species with capacity to bind P — i.e. the reduction of Fe(III) to Fe(II). Importantly, a significant fraction of the reductive process can be linked to the microbial heterotrophy of sedimentary OM. As such, the utilization of Fe as terminal electron acceptor for the oxidation of OM exerts a critical role in P solubilisation. Here we present a proposed study based on preliminary results aimed at investigating the fate of OM in lacustrine sediments. The sedimentary OM and its associated minerals would be characterized via pyrolysis gas chromatography-mass spectrophotometry and scanning electron microscopy, respectively. Enzymatic and molecular techniques would be used in studying the pathway utilised by microbes within the vertical profile. The combined dataset, alongside anion concentrations and information provided by Fe and P speciation analyses would significantly enhance our understanding on the mechanism associated with the preservation of OM and thereby offer avenues for further improving the quality of the freshwater systems.

EFFECTS OF CHRONIC PHOSPHORUS LOADING ON IN-STREAM PHOSPHORUS UPTAKE AND RELEASE PROCESSES

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Chronic phosphorus loadings may alter in-stream phosphorus uptake kinetics considerably. While uptake rates are generally expected to follow saturation kinetics, adaptions of the periphyton to enhanced SRP concentrations may move the saturation point to higher SRP concentrations. In contrast, phosphorus loadings may reduce the sorption capacity of the sediments. The aim of our study was to analyze the effects of chronic phosphorus loading on phosphorus uptake kinetics with specific regard to potential adaption and saturation phenomena.

Uptake kinetics were studied via consecutive plateau additions with increasing phosphorus concentrations in 9 headwater streams along a land use gradient in spring and summer 2015. In 2016, we performed slug additions in 7 of the streams and calculated uptake kinetics via the TASCC approach ("Tracer Additions for Spiraling Curve Characterization"). Sorption processes were analyzed via adsorption experiments. Additionally, we determined benthic algal and bacterial abundances and phosphatase activities.

Highly impacted streams flowing through cropland showed signs of nutrient saturation, indicated by high ambient uptake rates, but extremely low uptake at concentrations above background. Moderately impacted streams in catchments dominated by pasture were characterized by medium uptake rates which were maintained over a wide range of SRP concentrations. In both catchment types, uptake rates from slug additions usually followed Michaelis-Menten kinetics, but sometimes showed hysteresis with decreased rates in the falling limb. In contrast, uptake rates in pristine systems followed a power function and exhibited hysteresis with increased rates in the falling limb.Zero equilibrium phosphorus concentrations increased with increasing SRP loading.

THERMAL VARIABILITY DRIVES CO2 EVASION FROM ALPINE COLDWATER STREAMS

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Gravel bars (GB) are capable of absorbing and transferring heat to the underlying hyporheic zone (HZ). We studied seasonal and diurnal thermal and CO2 flux variability within an Alpine cold water stream (Oberer Seebach, Austria - OSB) over the course of a year and conducted spot sampling at this and 12 other gravel bars within the surrounding catchments. We found the vertical temperature profiles within the OSB to vary seasonally and with discharge. Temperatures within the active (wetted) hyporheic zone of the OSB were warmer than both end members, surface water and groundwater >18% of the year. CO2 fluxes from the GB varied spatially and temporally, and average daily and seasonal fluxes exceeded that of its stream. Higher temperature gradients were associated with increased CO2 evasion fluxes within the OSB, particularly during summer. This is likely the result of downward heat transfer in the GB in summer, potentially enhancing GB metabolism and therefore CO2 evasion. Per unit area CO2 fluxes from all 13 GBs studied exceeded that of their streams. Vertical temperature gradient as a measure of heat flux to the hyporheic zone explained 55% and 69% of the variability in observed CO2 efflux from the OSB (seasonal samplings during summer 2015 – winter 2016) and during spot sampling. These results highlight the effect of increasing temperature on physical and biochemical stream processes, and are increasingly important due to the occurrence of more frequent and intense warm temperature events, as well as altered flow regimes, likely consequences of climatic change.

SELECTIVE LOSS OF DISSOLVED ORGANIC MATTER ALONG THE BOREAL INLAND WATER CONTINUUM - THE ROLE OF SORPTION TO INORGANIC SURFACES

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Organic matter is continuously transformed and mineralised as it is transported from soils to the ocean. Mechanisms that are responsible for these changes include microbial degradation, photochemical degradation, flocculation and sorption to mineral surfaces. However, the relative contribution of each of these processes to observed changes in dissolved organic matter (DOM) composition are poorly known, as is the spatial distribution of these processes along the aquatic continuum. Substantial efforts have been made to estimate the importance of microbial and photochemical degradation, and to some extent also DOM losses by flocculation, whereas the possible role of sorption to clay and other inorganic surfaces has received limited attention in freshwater systems. Here, we assess the potential reactivity of dissolved organic matter (DOM) towards clay sorption along a water retention time gradient in the boreal landscape of Sweden. We hypothesize that the potential for sorption is gradually exhausted with increasing water residence time. Our results suggest that DOM is highly susceptible to sorption throughout the aquatic continuum. However, freshly produced DOM seems less susceptible to sorption than more humified material. The results suggest that the capacity for sorption greatly exceeds the actual sorption taking place in boreal inland waters. This implies that these waters are sensitive to the effects of mineral erosion, for example as a result of agriculture, mining and other types of encroachment.

A NETWORK-SCALE PERSPECTIVE IS REQUIRED TO FULLY UNDERSTAND CARBON SOURCES, TRANSFORMATIONS, AND FATE IN FRESHWATERS

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In-stream biological processes alter the quantity and quality of organic carbon (OC) inputs from land before they are transported downstream. Measurements of metabolism, CO2, and OC fluxes can be used to estimate (1) the distance OC travels before being consumed and respired as CO2 through biological processes (i.e., OC spiraling) and (2) the proportion of CO2 derived from respiration on land versus in stream, allowing for a more mechanistic understanding of the role of ecosystem processes in modifying CO2 emissions and downstream OC transport. Here we present multi-season ecosystem metabolism, DOC and CO2 flux, and OC spiraling data and simulations from a boreal stream network to demonstrate not only the role of in-stream processes in governing OC flux and fate, but also how we may use linked sampling sites within networks to better understand the integrated sources and fate of OC in freshwaters. Without knowledge of upstream inputs and processing, we cannot fully understand the complex history of carbon at downstream sites or acknowledge the mixture of upstream external inputs and in-stream processes that contribute to downstream fluxes. Indeed, we bias our estimates of CO2 inputs from land when some CO2 in transport is from upstream respiration. We present a framework for future considerations of integrated carbon transport, transformations, and fate when scaling patterns and processes to river networks.

EXPLORING THE RELATIONSHIP OF HYDRAULIC CONDUCTIVITY AND NITROGEN UPTAKE IN THE HYPORHEIC ZONE: FROM MICROHABITAT TO REACH-SCALE

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The hyporheic zone (HZ) supports essential functions for river ecosystems, such as nutrient retention. Excessive fine inputs to streams and the subsequent physical alteration of HZ (i.e. clogging) and HZ functions is today a major environmental issue. Because most of the knowledge on HZ physical structure and function is limited to fine-scale approaches, and it is unclear to what extent patterns at a particular scale emerge at larger scales, we lack understanding of the significance of physical alterations of HZ at the reach-scale. This limits cross-system comparisons and our ability to manage HZ efficiently. We addressed this knowledge gap by exploring the relationships between ammonium uptake and HZ hydraulic conductivity (Kf) at the microhabitat and reach-scale. Based on a quantitative and transferable method for measuring reach-scale Kf, we selected six reaches differing in Kf. At each reach simultaneously at the microhabitat and reach-scale, we assessed Kf, hyporheic exchange and ammonium uptake. Preliminary results suggest that while at the reach-scale ammonium uptake tended to be 4× higher in high-Kf reaches (0.04 m/s) than in low Kf ones (0.0001 m/s), this pattern do not emerge at the microhabitat-scale thus imposed by smaller-scale influences (e.g. organic matter content). Since the impact of clogging is assessed and managed at the reach-scale, our results point to reach-scale Kf as promising for studying HZ physical alterations and their functional implications, such as clogging across stream monitoring networks.

DRIVERS OF N UPTAKE IN ARCTIC STREAMS, NORTHERN SWEDEN

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Climate change in the arctic is predicted to alter the delivery of nutrients from terrestrial to aquatic ecosystems. The implications of such changes for downstream lakes and rivers is influenced by the capacity of small streams to retain nutrients. Here we ask how abiotic conditions and metabolic activity influence patterns of nitrate (NO3-) uptake in arctic streams of northern Sweden. We explored this in two headwater streams at different altitude (750 and 300 m.a.s.l with tundra and birch forest, respectively) by measuring NO3- uptake biweekly from June to October using short-term slug releases. Oxygen concentration was continuously recorded to determine rates of GPP and R, and ceramic tiles were deployed to estimate algal accrual. The tundra stream had higher average incident light (18 vs 8 mol photons m-2 day-1), higher NO3- variability (average 46 vs 70 µg L-1, coefficient of variation 94 vs 52%) and temperatures (5 vs 7 °C), and 3-times lower rates of algal accrual compared to the birch forest stream. Preliminary analysis suggest strong daily-to-seasonal variation in metabolic rates and NO3- uptake varied considerably within and between sites ranging from 0.1 to 77 µg N m-2 min-1. Together, these results highlight important spatial heterogeneity in streams within arctic landscapes linked to landscape position and local geomorphic setting. Although arctic streams experience unfavorable physical conditions for biotic processing we show that in-stream productivity can exert control on the downstream transport of N.

HIGH RESOLUTION MEASUREMENTS OF CO2 FLUXES IN AN ARCTIC STREAM NETWORK REVEAL HIGH SPATIAL VARIABILITY

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CO2 evasion to the atmosphere from inland waters is an important component in the carbon cycle, and streams and rivers account for more than 85% of this flux. Headwater streams are hotspots for CO2 evasion, but extreme spatiotemporal variability in their physical properties can make upscaling of CO2 evasion from stream networks very uncertain. Here we estimated CO2 fluxes across a 42 km long tundra-forest stream network in northern Sweden, from springs to 4th order streams, to better understand how stream functional traits affects CO2 emissions. We measured pCO2, alkalinity, 13C-DIC, and key hydrological parameters at a 30-400 m resolution in summer 2016. The pCO2 varied tenfold, from 380 to 3400 µatm, and was largely influenced by terrestrial connectivity and turbulence. The gas transfer velocity varied two orders of magnitude, from 2 to 285 dm day-1, and pCO2 concentrations declined exponentially with this estimate of water-atmosphere exchange. 13C-DIC values ranged from-1.7 to -21.9 ‰ vs PDB and were linearly related to log[pCO2] indicating that degassing and/or in-situ stream processes are important regulators of CO2 concentration. In order to accurately estimate CO2 evasion from inland waters we need to quantify and reduce the uncertainty of CO2 fluxes. Hence, our data highlight where hotspots of CO2 evasion are positioned in the landscape and enable us to better understand and predict CO2 fluxes at a multiscale level, from stream to the catchment and further, to a regional scale.

SCALING BIODIVERSITY RESPONSES TO HYDROLOGICAL REGIMES

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Understanding natural and anthropogenic factors driving patterns of biodiversity is a fundamental goal in ecology. Despite the importance of the hydrological regime for aquatic ecosystems being well understood, we still lack a clear and unified conceptual understanding of how hydrology influences aquatic biodiversity from regional to local spatial scales. Much of our current understanding is based on the taxonomic and functional richness of communities at individual locations and how these facets of biodiversity are shaped by natural hydrological disturbances (e.g. floods, droughts) or altered by anthropogenic changes to hydrological regimes due to human water use and hydrological regulation. We review and synthesise published literature on hydrology-biodiversity relationships to (i) determine how scale-dependent components of freshwater biodiversity respond to hydrological gradients and hydrological regimes and (ii) identify the specific underlying ecohydrological mechanisms responsible for patterns of biodiversity across spatial scales. Different ecohydrological mechanisms vary in their effect on freshwater biodiversity across spatial scales; hydrological disturbance regime is an important driver of biodiversity across local-regional scales, and both hydrological connectivity and the effect of hydrology on habitat strongly influence landscape and local scale biodiversity. We highlight that there remains a lack of research to understand how hydrological regimes influence both functional and phylogenetic aspects of freshwater communities across spatial scales and identify six research priorities necessary to improve our understanding of multi-scaled biodiversity responses to hydrological regimes. Addressing these gaps in understanding is critical, as a central goal of freshwater conservation policy is to manage hydrological regimes to protect or enhance freshwater biodiversity.

HOW WELL DO PATCH-SCALE LITTER BREAKDOWN RATES PREDICT EFFECTS OF EXCESS NUTRIENTS ON TERRESTRIAL CARBON LOSS FROM WHOLE STREAMS

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Excess nutrients (nitrogen [N] and phosphorus [P]) accelerate loss of terrestrial detrital carbon (C) from stream ecosystems, but appropriate tools and assays to gauge the scale of this important whole-ecosystem response require assessment and validation. To evaluate the use of litterbag studies as indicators of the effects of N and P on whole-stream C loss, we compared breakdown rates (k) from litterbags in streamside channels and natural streams with rates of annual whole-stream C loss. In all studies, we found significant effects of both N and P on rates of breakdown (litterbags) and annual C loss (whole streams), with P effects consistently greater (1.4-2.0) than N effects based on standardized parameter estimates. We also compared litterbag breakdown rates of single litter species to whole-stream C loss rates and found steeper slopes and the best fits (e.g., R2 = 0.6) to whole-stream rates using the lowest quality litter species. Steeper slopes were likely due to relatively greater effects of nutrients on breakdown of lower quality litter, while best fits of low-quality litter with whole-stream loss rates may have been a function of their longer term (multi-year) availability and retention in our study streams. Our studies provide support for the use of litterbag studies in gauging the effects of N and P enrichment on larger-scale C loss processes. Our results also suggest that low-quality litter species may be most sensitive in their responses and so capture whole-stream loss dynamics most accurately. Thus, they may be most useful in monitoring and management applications.

ON THE RELEVANCE OF THE STRESSOR CONTEXT FOR UPSCALING ECOSYSTEM FUNCTIONS

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Freshwater ecosystems are influenced by a multitude of anthropogenic stressors, which, by and large, are associated with land use. We present the result of several field studies in small streams from South-East Australia, Central and North Europe on the relationship between anthropogenic stressors (e.g. land use, toxicants and climate change) and the ecosystem function of leaf decomposition to discuss the following questions: Is land use information sufficient to predict ecosystem functioning? Can we infer ecosystem functioning from functional community composition? To which extent do traits and stressor-ecosystem functioning relationships converge across biogeographical regions? We show that in a study on 30 low-order streams in a region of contrasting land use, land use affected the taxonomic diversity of both microbial and invertebrate decomposers, but was a poor predictor of microbial and invertebrate leaf decomposition, whereas specific environmental stressors exhibited a strong predictive potential. The functional community composition was only in some field studies related to ecosystem functioning and we discuss potential explanations. Finally, we found general trait convergence to stressors integrating data from several field studies as well as in some cases similar relationships between ecosystem functioning and stressors across biogeographical regions. Overall, the environmental stressor context can inform the upscaling of ecosystem functioning, while functional community descriptors may be too crude (lack of biomass data and coarse trait information on larger scales), and we present first results for upscaling the impairment of leaf decomposition by stressors on the continental scale.

CARBON DIOXIDE EVASION FROM A CENTRAL EUROPEAN RIVER SYSTEM: ADVANCES IN IDENTIFYING AND INCORPORATING DYNAMIC EVASION HOT-SPOTS AT DIFFERENT SCALES

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Streams and rivers contribute substantially to carbon dioxide (CO2) inputs to the atmosphere. However, high spatio-temporal variability and considerable uncertainties in flux estimates challenge deriving representative projections for entire fluvial networks. Here we summarize work on CO2 evasion at various spatial scales spanning from small headwater streams to the main stem of the Central European Danube River. In headwater streams our results demonstrate CO2 evasion being dependent on seasonal and diurnal variation in pCO2 and reach-specific variability in piston velocity. Furthermore, distinct geomorphological features such as in-stream gravel bars could be identified as important sources of CO2. Outgassing rates from the studied structures outweighed the per area flux of stream water at some occasions. On the spatial scale of the higher-order Danube River, we found floodplains to represent important areas of CO2 evasion. Here, CO2 outgassing was dependent on the connectivity of a floodplain to the main river, resulting in shifts in CO2 evasion between the floodplains and the main stem during pre, peak and post flood conditions. Overall, we conclude that various hot-spots and their temporal dynamics need to be incorporated in local to global scale CO2 evasion estimates from fluvial ecosystems. With geomorphological restauration measures being on the rise in many European streams and rivers, our findings receive additional relevance.

FOOD WEBS IN LARGE RIVERSCAPES: THE IMPORTANCE OF SCALE WHEN MATCHING FOOD RESOURCE AVAILABILITY TO CONSUMER DEMAND

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Food webs are composed of a multitude of species interactions that can be dispersed over broad areas yet many river food-web studies are commonly carried out at confined spatial scales. Geographically constrained sampling may lead to inaccurate estimates of resource availability for consumers by missing important subsidies entering from outside the boundaries of sampling reaches or by failing to explicitly consider the foraging extent of mobile consumers. Few studies have examined the interaction between spatial heterogeneity of resources and the foraging extent of mobile consumers in large river food webs. However, this approach is necessary in the context of estimating energy supply relative to demand in diverse food webs. To address this disconnect, we combined detailed benthic habitat maps with estimates of macroinvertebrate production across large segments (>10 km) of the Missouri and Yellowstone rivers, MT. Additionally, we estimated movement via mark-recapture data, diets, and abundances of Pallid Sturgeon (Scaphirhynchus albus) to quantify energetic demand. This framework allowed us to examine the consequences of scaling up estimates of resource supply sampled at relatively small scales to match the movement and energetic demand of Pallid Sturgeon at much larger scales. Our results indicate that Pallid Sturgeon home ranges may extend far beyond the typical extent of most traditional benthic sampling. Furthermore, we found that the spatial scale of resource sampling altered estimates of energetic supply versus demand. Our results underscore the need for careful consideration of sampling and scaling methods when examining energetic food webs across large spatial scales.

SCALING NUTRIENT TRANSPORT AND RETENTION IN STREAM AND RIVER NETWORKS: AN OVERVIEW AND NEW DIRECTIONS

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Predicting ecological conditions in lotic ecosystems requires a better understanding of how drivers of stream structure and function observed locally sum to influence patterns observed at broad spatial (watershed-to-global) and temporal (days-to-decades) scales. In this presentation, we review our current understanding of nutrient transport and transformation in stream ecosystems and how hydrology, geomorphology, and watershed biogeochemical patterns can help scale local measurements. Recent synthetic studies have demonstrated how combining metrics of nutrient spiraling with hydrogeomorphic scaling functions help predict network scale variation in the nutrient transport distance and biological uptake rates. In this presentation, we summarize basin-scale patterns of metabolic activity and explore whether these patterns help explain the residual variation in the relationship between nutrient cycling and hydrogeomorphic patterns. This assessment is currently underway, but preliminary analysis suggest that predicted patterns in photosynthetic activity may help explain where and when nutrient retention exceeds predicted rates based on hydrological and geomorphological relationships. These results suggest that predicting basin scale patterns in stream ecosystems will be improved by understanding how specific functions interact in nature.

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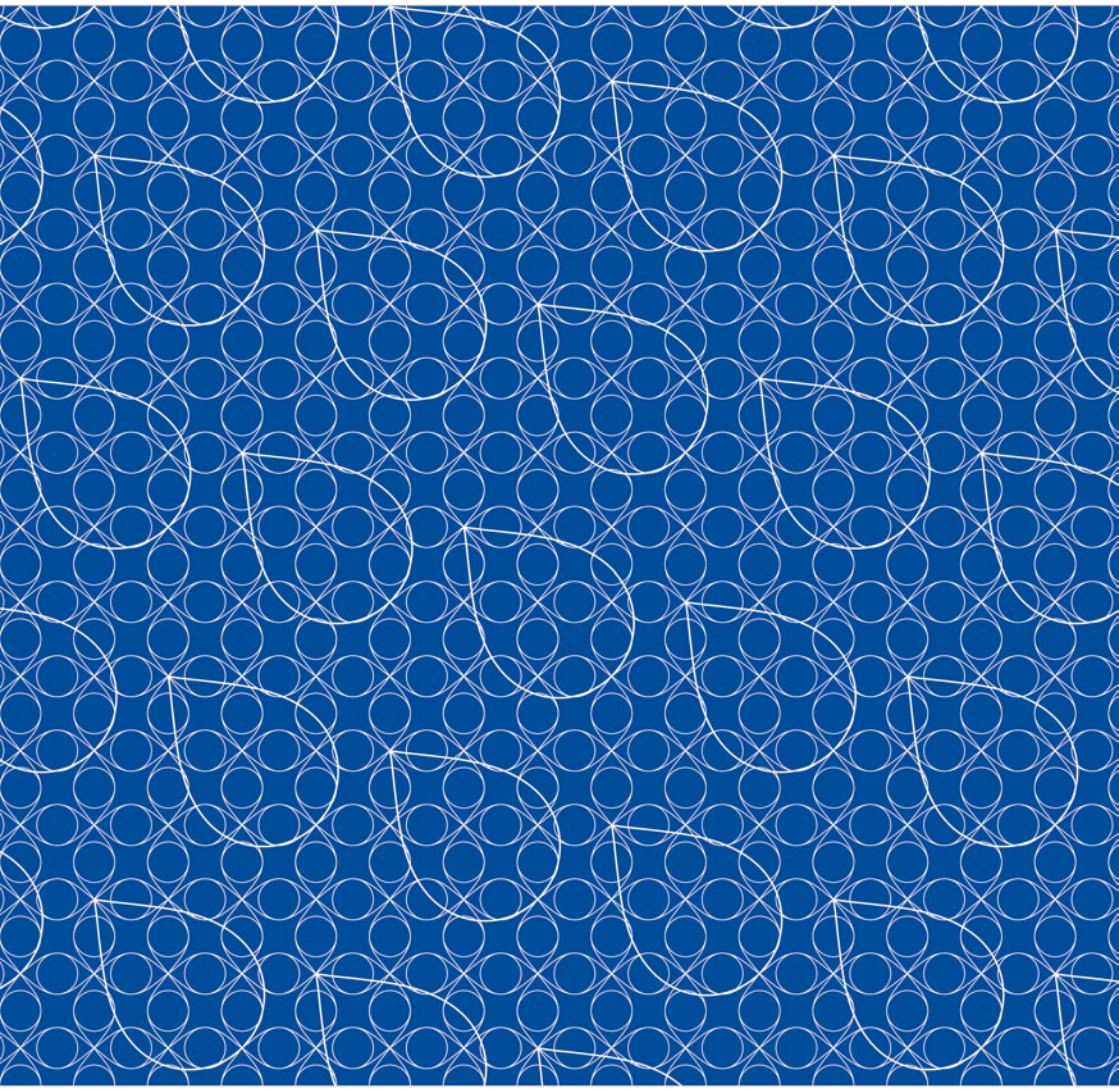

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